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# Iron & Steel Technology®


• Maintenance and Reliability

A Publication of the Association for Iron & Steel Technology

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# Iron & Steel Technology



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## Maintenance & Reliability




# ON THE COVER

Brian Smith of ANDRITZ Herr-Voss Stamco Inc.'s shapemeter maintenance facility in Ambridge, Pa., USA, pictured with ANDRITZ's flatness measurement and flatness control system. ANDRITZ'S shape control systems are used in various kinds of rolling mills and process lines in the metals industry for modernization, repair, refurbishment, testing, simulations, virtual reality training and artificial intelligence remote services.

*Photo courtesy of* ANDRITZ

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# IN OUR NEXT ISSUE

## Long Products Rolling Technologies

Iron & Steel Technology
















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# Navigating the Course Ahead

To the AIST Community,

As previously announced, the AIST Board of Directors made the difficult decision last month to cancel AISTech 2020 — The Iron & Steel Technology Conference and Exposition as scheduled for 31 August–3 September in Cleveland, Ohio, USA.

AISTech represents one of the world's largest in-person learning platforms for iron and steel technology. It is also a networking catalyst whereby many companies, large and small, generate the business that drives the steel economy. While we may be disheartened by the decision, the rationale for canceling the event was sound in light of the pervasive COVID-19 pandemic and the many unique in-person programs that define AISTech. As an industry, Safety First shall always prevail.

We want to thank our many attendees, presenters, exhibiting companies and sponsors for their unwavering commitment to AIST through this unprecedented situation. Your encouragement and support of AIST and the steel industry is genuinely appreciated.

As human beings, and as representatives of the steel industry, we must all continue to navigate — with a steady hand — the uncertainty of these times. Through it all, there is a valuable lesson to be learned: "Life is 10% what happens to us, and 90% how we react to it."

Though COVID-19 can never change AIST's mission and vision, it has changed the way we will serve and provide value to our membership. In recent months, the AIST Board of Directors and the AIST Foundation Board of Trustees have guided the strategic integration of our conventional programs with virtual technology platforms.

In this regard, we have launched virtual meeting platforms for each of our 30 Technology Committees. In addition, AIST now provides weekly webinars, crossing the full spectrum of iron and steel technology while also reaching a global audience. As we look ahead, our upcoming schedule includes a full lineup of fundamental technology training courses, many of which will be offered with a hybrid format.

AIST remains committed to providing our global steel community with valuable networking and educational experiences, whether in-person, virtually or a hybrid combination of both. We will leverage our immense bandwidth to disseminate knowledge, share ideas and raise our collective level of performance.

The opportunities for steel to succeed are endless, and we look forward to your continued participation!

Sincerely,

Ronald J. O'Malley

Ronald J. O'Malley
F. Kenneth Iverson Chair
Professor in Steelmaking Technologies and director, Kent D. Peaslee Steel Manufacturing Research Center
Missouri University of Science and Technology

AIST President
2019–2020

Missouri S&T

AIST Association for Iron & Steel Technology

## Also in the News

- ***Stelco Inc.*** is partnering with ***DTE Energy Services Inc.*** on construction of a 65-MW cogeneration plant at the steelmaker's Lake Erie Works in Ont., Canada, Stelco has announced. Under the agreement, DTE will provide the capital for the plant, and Stelco will pay DTE a fixed annual fee under a 20-year energy services agreement. Construction is to start this summer, and the plant is to come on-line in the first half of 2022. "Once operational, the cogen plant is expected to reduce Stelco's energy costs and further enhance the utilization of Stelco's process-generated offgases," Stelco said.

- ***The Systems Group*** has been awarded a contract to upgrade a Texas electric arc furnace (EAF). In a statement, The Systems Group said its Systems Spray-Cooled unit will outfit ***Optimus Steel's*** Beaumont, Texas, USA,, EAF with a Spray-Cooled™ electric arc furnace roof and a new Spray-Cooled elbow. It also will make other engineering improvements. "This project is expected to be the first phase of a multi-phase meltshop upgrade to a more optimized design with the upper shell and offgas system to follow," The Systems Group said in a statement.

## Big River Steel announces partnership with Koch Metallics

North America — Big River Steel has signed an agreement that will make a Koch family business the steelmaker's exclusive metallics procurement agent.

In a statement, Big River said the agreement with Koch Metallics, a subsidiary of Koch Minerals & Trading, will allow it to improve its metallics procurement by leveraging Koch's networks, capabilities and potential for providing additional services in support of Big River Steel's growth initiatives.

"Entering into this agreement will accelerate several initiatives Big River Steel has underway that provide alternatives to the ways metallics and flat-rolled steel have historically been bought and sold," said Big River Steel chief executive David Stickler.

Koch is a major investor in Big River Steel.

"I look forward to broadening our relationship as we jointly advance in the metallics space," Stickler said.

With the agreement in place, Big River metallics procurement manager Martin Baker will join the Koch team as metallics procurement and conversion manager.

"Martin is a proven professional, and I am fully confident that Martin joining the Koch team will lead to new and expanded relationships with forward-thinking domestic and international metallics providers and steel consumers," said Stickler.

## ArcelorMittal lays out European climate action plan

Europe — ArcelorMittal Europe intends to become carbon neutral in the next 30 years by transitioning to a direct reduction–based production route and by investing in technology and equipment to store or recycle its carbon output.

"By investing in both routes — and in recognition of the need to act now to combat climate change — this means ArcelorMittal Europe can significantly reduce $CO_2$ emissions by 2030 over a 2018 baseline, while waiting for the large-scale, affordable renewable energy needed for hydrogen-based steelmaking," the company said in its newly released climate action road map in Europe.

ArcelorMittal said the effort represents an investment of EUR45 billion to EUR65 billion. The company also is calling on EU leaders to help establish an environment that supports clean steelmaking.

That environment, it said, would include access to abundant, affordable clean energy and a level playing field that "accounts for the global nature of the steel market, addressing domestic, import and export steel dynamics, as well as the distinction between primary and secondary sources to make steel."

"Today, the biggest barrier to transitioning to carbon-neutral steel, beyond the necessary technologies reaching commercial maturity, is the absence of the right market conditions," said Geert Van Poelvoorde, chief executive of ArcelorMittal Europe – Flat Products.

"The financial costs of realizing carbon-neutral steelmaking are undeniably huge. However, with a shift in market conditions brought about by having the right policies in place, European steelmakers will be able to unlock the means to reduce emissions from steel globally, while also ensuring the European steel industry remains competitive."

## Nippon Steel schedules blast furnace reline

Asia — Nippon Steel Corp. has announced plans to reline the No. 3 blast furnace at its Nagoya Works in southern Japan.

The company said the US$452 million project is intended to maintain the facility's competitiveness.

"After the relining, advanced IT and other leading-edge technologies from Japan and abroad will be adopted in the No. 3 blast furnace to realize stable production and higher productivity," the company said.

"The Nagoya Works is one of the world's leading steel works in optimal integrated manufacturing technology of steel sheets for automobiles. It is also positioned as Nippon Steel's main integrated manufacturing base of high-grade steel sheet, with competitive capability in product development and response to customers. The Nagoya Works plays a role by supplying upstream-processed materials of high-grade steel sheet to other steel works," it added.

The project has been scheduled for the first half of 2022.

## GFG Alliance accelerates carbon reduction investment plans

Global — GFG Alliance is stepping up investment plans in Europe and Australia as it looks to modernize plants and make them more sustainable and efficient, the company has announced.

"GFG Alliance reaffirms its commitment to develop environmentally sustainable GREENSTEEL, GREENALUMINIUM and to progress toward carbon neutrality, as a group, by 2030. The pandemic has underlined the need to modernize plants to make them more flexible and efficient, which goes hand in hand with investment in low-carbon technology for us," it said.

To that end, the company said that within the next three to five years, it will build a direct reduced iron plant and install two electric arc furnaces at LIBERTY Steel Galati in Romania and construct what the company said will be Europe's first hybrid furnace, blending electric arc and blast furnace steelmaking, at its Ostrava plant in the Czech Republic.

Additionally, the company plans to invest in an electric arc furnace and a direct reduction plant at its integrated Whyalla plant in Australia. The company said the new ironmaking and steelmaking facilities will complement its planned construction of a new heavy-section combination rolling mill there. ✦

## Top Steel-Producing Companies in 2019 (in million metric tons)

| | | 2019 | | 2018 | | |
|---|---|---|---|---|---|---|
| Company | Country | Rank | MT | Rank | MT | y-o-y % change |
| ArcelorMittal[1] | Luxembourg | 1 | 97.31 | 1 | 96.42 | 0.90 |
| China Baowu Group[2] | China | 2 | 95.47 | 2 | 67.43 | 41.60 |
| Nippon Steel Corp.[3] | Japan | 3 | 51.68 | 3 | 49.22 | 5.00 |
| HBIS Group[4] | China | 4 | 46.56 | 4 | 46.80 | (0.50) |
| POSCO | South Korea | 5 | 43.12 | 5 | 42.86 | 0.60 |
| Shagang Group | China | 6 | 41.10 | 6 | 40.66 | 1.10 |
| Ansteel Group | China | 7 | 39.20 | 7 | 37.36 | 4.90 |
| Jianlong Group | China | 8 | 31.19 | 9 | 27.88 | 11.90 |
| Tata Steel Group | India | 9 | 30.15 | 11 | 27.27 | 10.60 |
| Shougang Group | China | 10 | 29.34 | 10 | 27.34 | 7.30 |
| Shandong Steel Group | China | 11 | 27.58 | 13 | 23.21 | 18.80 |
| JFE Steel Corp. | Japan | 12 | 27.35 | 8 | 29.15 | (6.20) |
| Valin Group | China | 13 | 24.31 | 14 | 23.01 | 5.60 |
| Nucor Corp. | United States | 14 | 23.09 | 12 | 25.49 | (9.40) |
| Hyundai Steel | China | 15 | 21.56 | 15 | 21.88 | (1.50) |
| IMIDRO[5] | Iran | 16 | 16.79 | 19 | 16.79 | 0 |
| JSW Steel Ltd. | India | 17 | 16.26 | 18 | 16.83 | (3.40) |
| Steel Authority of India Ltd. (SAIL) | India | 18 | 16.18 | 20 | 15.93 | 1.60 |
| Benxi Steel | China | 19 | 16.18 | 21 | 15.90 | 1.80 |
| Fangda Steel | China | 20 | 15.66 | 24 | 15.51 | 1.00 |
| NLMK | Russia | 21 | 15.61 | 17 | 17.39 | (10.20) |
| Baotou Steel | China | 22 | 15.46 | 27 | 15.25 | 1.40 |
| China Steel Corp. | Taiwan | 23 | 15.23 | 22 | 15.88 | (4.10) |
| Techint Group | Argentina | 24 | 14.44 | 25 | 15.38 | (6.10) |
| Liuzhou Steel | China | 25 | 14.40 | 29 | 13.53 | 6.40 |
| Rizhao Steel | China | 26 | 14.20 | 28 | 14.95 | (5.00) |
| United States Steel Corporation | United States | 27 | 13.89 | 26 | 15.37 | (9.60) |
| EVRAZ | United Kingdom | 28 | 13.81 | 30 | 13.02 | 6.10 |
| CITIC Pacific Special Steel | China | 29 | 13.55 | 33 | 12.55 | 8.00 |
| Gerdau | Brazil | 30 | 13.13 | 23 | 15.08 | (12.90) |
| Jingye Steel | China | 31 | 12.58 | 37 | 11.25 | 11.80 |
| MMK | Russia | 32 | 12.46 | 31 | 12.66 | (1.60) |
| Shaanxi Steel | China | 33 | 12.45 | 36 | 11.38 | 9.40 |
| Sanming Steel | China | 34 | 12.40 | 35 | 11.68 | 6.20 |
| thyssenkrupp | Germany | 35 | 12.25 | 32 | 12.58 | (2.60) |
| Zenith Steel | China | 36 | 11.93 | 48 | 8.03 | 48.60 |
| Severstal | Russia | 37 | 12.04 | 34 | 12.04 | 0 |
| Tsingshan Stainless Steel | China | 38 | 11.40 | 44 | 9.29 | 22.70 |
| Nanjing Steel | China | 39 | 10.97 | 41 | 10.05 | 9.20 |
| Taiyuan Steel | China | 40 | 10.86 | 39 | 10.70 | 1.50 |
| Anyang Steel | China | 41 | 10.54 | 38 | 10.97 | (3.90) |
| Metinvest Holding | Ukraine | 42 | 9.56 | 42 | 9.37 | 2.00 |
| Xinyu Steel | China | 43 | 9.47 | 43 | 9.36 | 1.20 |
| Donghai Special Steel | China | 44 | 8.90 | 50 | 7.61 | 17.00 |
| Jinxi Steel | China | 45 | 8.73 | 40 | 10.33 | (15.50) |
| Erdemir Group | Turkey | 46 | 8.61 | 45 | 9.14 | (5.80) |
| Steel Dynamics Inc. | United States | 47 | 8.59 | 46 | 8.92 | (3.70) |
| Kunming Steel | China | 48 | 7.73 | — | — | — |
| SSAB | Sweden | 49 | 7.62 | 47 | 8.70 | (12.40) |
| Jiuquan Steel | China | 50 | 7.48 | — | — | — |

[1]Includes shares in AM/NS India and China Oriental.
[2]Includes tonnage of Maanshan Steel and Chongqing Steel.
[3]Includes tonnage of Nippon Steel Stainless Steel Corp., Sanyo Special Steel and Ovako AB, and shares in AM/NS India and USIMINAS.
[4]Includes tonnage of Serbia Iron & Steel d.o.o. Beograd and MAKSTIL A.D. in Macedonia.
[5]Combined tonnage of Mobarrakeh Steel, Esfahan Steel, Khuzestan Steel and NISCO.

Source: World Steel Association

# Industry Statistics

## Major Steel-Producing Countries in 2019 (in million metric tons)

| | 2019 | | 2018 | | 2014 (5 years) | | 2009 (10 years) | |
|---|---|---|---|---|---|---|---|---|
| Country | Rank | MT | Rank | MT | Rank | MT | Rank | MT |
| China | 1 | 996.3 | 1 | 928.3 | 1 | 822.7 | 1 | 567.8 |
| India | 2 | 111.2 | 2 | 106.5 | 4 | 86.5 | 3 | 62.8 |
| Japan | 3 | 99.3 | 3 | 104.3 | 2 | 110.7 | 2 | 87.5 |
| United States | 4 | 87.8 | 4 | 86.6 | 3 | 88.2 | 5 | 58.2 |
| Russia | 5 | 71.9 | 6 | 71.7 | 6 | 71.5 | 4 | 60.0 |
| South Korea | 6 | 71.4 | 5 | 72.5 | 5 | 71.5 | 6 | 48.6 |
| Germany | 7 | 39.7 | 7 | 42.4 | 7 | 42.9 | 7 | 32.7 |
| Turkey | 8 | 33.7 | 8 | 37.3 | 8 | 34.0 | 10 | 25.3 |
| Brazil | 9 | 32.2 | 9 | 34.9 | 9 | 33.9 | 9 | 26.5 |
| Iran | 10 | 25.6 | 11 | 24.5 | 14 | 16.3 | 16 | 10.9 |
| Italy | 11 | 23.2 | 10 | 24.5 | 11 | 23.7 | 11 | 19.8 |
| Taiwan, China | 12 | 22.0 | 12 | 23.2 | 12 | 23.1 | 12 | 15.9 |
| Ukraine | 13 | 20.8 | 13 | 21.1 | 10 | 27.2 | 8 | 29.9 |
| Vietnam | 14 | 20.1 | 17 | 14.1 | 26 | 5.7 | 41 | 2.0 |
| Mexico | 15 | 18.5 | 14 | 20.2 | 13 | 19.0 | 14 | 14.0 |
| France | 16 | 14.4 | 15 | 15.4 | 15 | 16.1 | 15 | 12.8 |
| Spain | 17 | 13.6 | 16 | 14.3 | 16 | 14.2 | 13 | 14.4 |
| Canada | 18 | 12.9 | 18 | 12.9 | 17 | 12.7 | 18 | 9.3 |
| Poland | 19 | 9.0 | 19 | 10.2 | 19 | 8.6 | 20 | 7.1 |
| Saudi Arabia | 20 | 8.2 | 28 | 5.2 | 25 | 6.3 | 28 | 4.7 |
| Belgium | 21 | 7.8 | 20 | 8.0 | 21 | 7.3 | 23 | 5.6 |
| Austria | 22 | 7.4 | 23 | 6.9 | 20 | 7.9 | 22 | 5.7 |
| Egypt | 23 | 7.3 | 21 | 7.8 | 24 | 6.5 | 24 | 5.5 |
| United Kingdom | 24 | 7.2 | 22 | 7.3 | 18 | 12.1 | 17 | 10.1 |
| Netherlands | 25 | 6.7 | 24 | 6.8 | 22 | 7.0 | 24 | 5.2 |
| Indonesia (e) | 26 | 6.4 | 27 | 5.5 | 38 | 2.8 | 34 | 3.5 |
| South Africa | 27 | 5.7 | 25 | 6.3 | 23 | 6.5 | 19 | 7.5 |
| Australia | 28 | 5.5 | 26 | 5.7 | 31 | 4.6 | 25 | 5.2 |
| Slovak Republic (e) | 29 | 5.3 | 29 | 5.2 | 30 | 4.7 | 33 | 3.7 |
| Sweden | 30 | 4.7 | 33 | 4.7 | 32 | 4.5 | 36 | 2.8 |
| Argentina | 31 | 4.6 | 30 | 5.2 | 27 | 5.5 | 32 | 4.0 |
| Malaysia (e) | 32 | 4.5 | 38 | 3.5 | 29 | 5.0 | 21 | 6.0 |
| Czech Republic | 33 | 4.4 | 31 | 4.9 | 28 | 5.4 | 29 | 4.6 |
| Thailand | 34 | 4.2 | 35 | 4.3 | 35 | 3.5 | 27 | 5.0 |
| Kazakhstan (e) | 35 | 4.1 | 34 | 4.6 | 34 | 3.7 | 30 | 4.1 |
| Finland | 36 | 3.5 | 36 | 4.1 | 33 | 3.8 | 35 | 3.1 |
| Romania | 37 | 3.4 | 37 | 3.5 | 36 | 3.2 | 37 | 2.8 |
| United Arab Emirates | 38 | 3.3 | 39 | 3.2 | 40 | 2.4 | — | — |
| Pakistan | 39 | 3.3 | 32 | 4.7 | — | — | — | — |
| Belarus | 40 | 2.6 | 41 | 2.5 | 39 | 2.5 | 38 | 2.4 |
| Qatar | 41 | 2.6 | 40 | 2.6 | 37 | 3.0 | 41 | 1.4 |
| Algeria | 42 | 2.4 | 45 | 2.0 | — | — | — | — |
| Luxembourg | 43 | 2.1 | 42 | 2.2 | 41 | 2.2 | 39 | 2.1 |
| Portugal | 44 | 2.0 | 43 | 2.2 | 42 | 2.1 | — | — |
| Oman (e) | 45 | 2.0 | 44 | 2.0 | — | — | — | — |
| Serbia | 46 | 1.9 | 47 | 2.0 | — | — | — | — |
| Hungary | 47 | 1.8 | 46 | 2.0 | 48 | 1.2 | 43 | 1.4 |
| Switzerland (e) | 48 | 1.5 | 48 | 1.5 | 44 | 1.5 | — | — |
| Philippines (e) | 49 | 1.4 | 49 | 1.5 | 45 | 1.4 | — | — |
| Greece | 50 | 1.4 | 50 | 1.5 | — | — | — | — |
| Others | — | 15.9 | — | 14.0 | — | — | — | — |
| **World** | | **1,868.8** | | **1,808.4** | | **1,645.1** | | **1,201.9** |

Source: World Steel Association

## World Crude Steel Production as of May 2020 (in thousand metric tons)

| | May | | | | Year to date | | | |
|---|---|---|---|---|---|---|---|---|
| | 2020 | 2019 | Change | % | 2020 | 2019 | Change | % |
| Austria | 540e | 646 | (106) | (16.4) | 2,839 | 3,331 | (491) | (14.7) |
| Belgium | 600e | 707 | (107) | (15.1) | 2,980 | 3,371 | (391) | (11.6) |
| Bulgaria | 50e | 56 | (6) | (10.7) | 258 | 252 | 6 | 2.5 |
| Croatia | 0e | 0 | 0 | 0 | 0 | 48 | (48) | (100) |
| Czech Republic | 365 | 401 | (36) | (9.0) | 1,939 | 2,050 | (111) | (5.4) |
| Finland | 235 | 374 | (139) | (37.2) | 1,540 | 1,651 | (111) | (6.7) |
| France | 784 | 1,235 | (451) | (36.5) | 4,796 | 6,391 | (1,595) | (25.0) |
| Germany | 2,565 | 3,513 | (948) | (27.0) | 14,982 | 17,312 | (2,330) | (13.5) |
| Greece | 100e | 130 | (30) | (23.1) | 473 | 636 | (163) | (25.6) |
| Hungary | 135 | 154 | (19) | (12.0) | 689 | 814 | (125) | (15.4) |
| Italy | 1,855 | 2,217 | (362) | (16.3) | 8,263 | 10,467 | (2,204) | (21.1) |
| Luxembourg | 160e | 201 | (41) | (20.3) | 758 | 991 | (233) | (23.5) |
| Netherlands | 487 | 610 | (123) | (20.1) | 2,718 | 2,923 | (204) | (7.0) |
| Poland | 700e | 807 | (107) | (13.2) | 3,342 | 4,134 | (793) | (19.2) |
| Slovenia | 32 | 56 | (24) | (43.5) | 251 | 278 | (26) | (9.5) |
| Spain | 833 | 1,256 | (423) | (33.7) | 4,716 | 6,246 | (1,530) | (24.5) |
| Sweden | 370 | 452 | (82) | (18.1) | 2,025 | 2,196 | (171) | (7.8) |
| United Kingdom | 700e | 636 | 64 | 10.1 | 3,130 | 3,182 | (52) | (1.6) |
| Other EU | 260e | 866 | (606) | (70.0) | 2,604 | 4,193 | (1,590) | (37.9) |
| **Total — European Union** | 10,770 | 14,315 | (3,545) | (24.8) | 58,303 | 70,465 | (12,162) | (17.3) |
| Bosnia-Herzegovina | 40e | 73 | (33) | (45.2) | 225 | 368 | (143) | (38.8) |
| Macedonia | 0 | 22 | (22) | (100) | 74 | 109 | (35) | (32.0) |
| Norway | 55e | 57 | (2) | (4.0) | 283 | 270 | 13 | 4.8 |
| Serbia | 115 | 185 | (70) | (38.0) | 626 | 862 | (236) | (27.4) |
| Turkey | 2,272 | 3,063 | (792) | (25.8) | 13,491 | 14,297 | (805) | (5.6) |
| **Total — Other Europe** | 2,481 | 3,401 | (919) | (27.0) | 14,699 | 15,905 | (1,207) | (7.6) |
| Belarus | 175e | 231 | (56) | (24.3) | 1,040 | 1,100 | (60) | (5.4) |
| Kazakhstan | 250e | 398 | (148) | (37.2) | 1,434 | 1,630 | (196) | (12.0) |
| Moldova | 30e | 30 | 0 | 1.0 | 133 | 146 | (13) | (8.9) |
| Russia | 6,000e | 6,302 | (302) | (4.8) | 29,850 | 30,232 | (382) | (1.3) |
| Ukraine | 1,638 | 1,827 | (189) | (10.4) | 8,295 | 9,270 | (975) | (10.5) |
| Uzbekistan | 80e | 56 | 24 | 42.9 | 398 | 248 | 150 | 60.5 |
| **Total — C.I.S. (6)** | 8,173 | 8,844 | (672) | (7.6) | 41,150 | 42,625 | (1,476) | (3.5) |
| Canada | 850e | 1,032 | (182) | (17.6) | 4,892 | 5,488 | (596) | (10.9) |
| Cuba | 15e | 18 | (3) | (15.2) | 83 | 88 | (6) | (6.6) |
| El Salvador | 8e | 8 | 0 | 0.5 | 39 | 41 | (1) | (3.6) |
| Guatemala | 20e | 24 | (4) | (17.8) | 113 | 124 | (11) | (8.6) |
| Mexico | 1,168 | 1,663 | (495) | (29.8) | 7,027 | 8,254 | (1,227) | (14.9) |
| United States | 4,912 | 7,553 | (2,641) | (35.0) | 31,452 | 37,069 | (5,617) | (15.2) |
| **Total — North America** | 6,973 | 10,298 | (3,324) | (32.3) | 43,606 | 51,064 | (7,457) | (14.6) |
| Argentina | 194 | 407 | (212) | (52.2) | 1,230 | 1,908 | (678) | (35.5) |
| Brazil | 2,188 | 2,826 | (639) | (22.6) | 12,141 | 14,442 | (2,300) | (15.9) |
| Chile | 90e | 83 | 7 | 7.9 | 434 | 322 | 112 | 34.7 |
| Colombia | 85e | 124 | (39) | (31.5) | 480 | 553 | (73) | (13.2) |
| Ecuador | 40e | 51 | (11) | (21.0) | 230 | 252 | (22) | (8.8) |
| Paraguay | 2e | 1 | 1 | 54.1 | 9 | 6 | 2 | 32.1 |
| Peru | 70e | 108 | (38) | (35.2) | 410 | 503 | (93) | (18.5) |
| Uruguay | 5e | 4 | 1 | 16.0 | 23 | 24 | (1) | (2.4) |
| Venezuela | 2e | 3 | (1) | (37.8) | 15 | 31 | (16) | (50.9) |
| **Total — South America** | 2,676 | 3,608 | (932) | (25.8) | 14,972 | 18,041 | (3,069) | (17.0) |
| Egypt | 628 | 651 | (23) | (3.6) | 3,518 | 3,494 | 25 | 0.7 |
| Iran | 2,368 | 2,158 | 210 | 9.7 | 11,461 | 10,297 | 1,165 | 11.3 |
| Libya | 47 | 46 | 1 | 1.4 | 197 | 226 | (29) | (12.9) |
| Qatar | 63 | 235 | (172) | (73.3) | 684 | 1,058 | (374) | (35.4) |
| Saudi Arabia | 565 | 706 | (141) | (19.9) | 3,269 | 3,468 | (199) | (5.7) |
| South Africa | 99e | 510 | (410) | (80.5) | 1,356 | 2,679 | (1,323) | (49.4) |
| United Arab Emirates | 164 | 291 | (128) | (43.9) | 1,135 | 1,365 | (230) | (16.8) |
| **Total — Africa/Middle East** | 3,933 | 4,596 | (663) | (14.4) | 21,621 | 22,587 | (965) | (4.3) |
| China | 92,267 | 88,565 | 3,702 | 4.2 | 411,751 | 403,975 | 7,776 | 1.9 |
| India | 5,767 | 9,468 | (3,701) | (39.1) | 35,851 | 47,543 | (11,692) | (24.6) |
| Japan | 5,916 | 8,674 | (2,758) | (31.8) | 36,604 | 42,292 | (5,688) | (13.4) |
| South Korea | 5,387 | 6,275 | (888) | (14.1) | 27,407 | 30,073 | (2,666) | (8.9) |
| Pakistan | 90e | 290 | (200) | (69.0) | 1,137 | 1,369 | (232) | (16.9) |
| Taiwan | 1,730e | 1,934 | (204) | (10.6) | 8,696 | 9,610 | (913) | (9.5) |
| Thailand | 350e | 428 | (78) | (18.1) | 1,823 | 1,736 | 87 | 5.0 |
| Vietnam | 1,949 | 1,750 | 199 | 11.4 | 9,016 | 8,846 | 170 | 1.9 |
| **Total — Asia** | 113,456 | 117,384 | (3,928) | (3.3) | 532,285 | 545,443 | (13,159) | (2.4) |
| Australia | 471 | 494 | (23) | (4.6) | 2,232 | 2,243 | (11) | (0.5) |
| New Zealand | 59 | 57 | 2 | 3.9 | 193 | 277 | (84) | (30.4) |
| **Total — Oceania** | 530 | 550 | (21) | (3.7) | 2,425 | 2,520 | (95) | (3.8) |
| **Total** | **148,992** | **162,996** | **(14,004)** | **(8.6)** | **729,060** | **768,650** | **(39,590)** | **(5.2)** |

Note: The countries included in this table accounted for approximately 99% of total world crude steel production in 2019.
e = estimate

Source: World Steel Association. Data as of 1 July 2020.

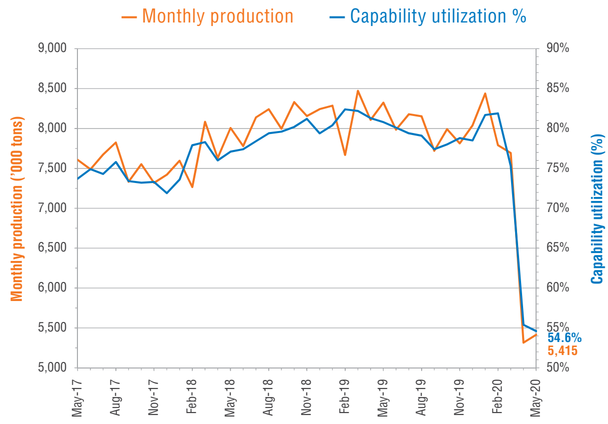


*Figure 1: U.S. monthly steel production and capability utilization.* Source: Platts.

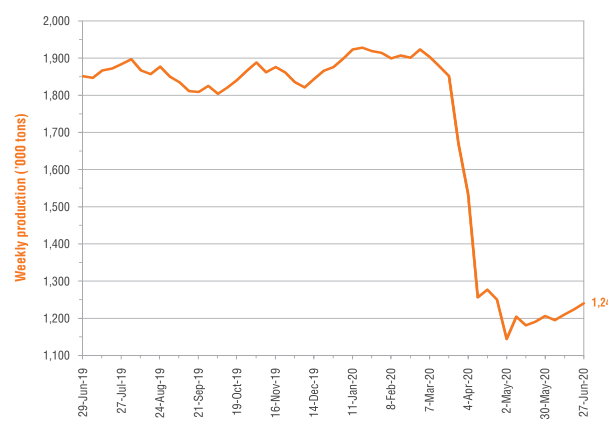


*Figure 2: U.S. weekly steel production.* Source: Platts.

## U.S. Production Capability and Imports

**Production —** U.S. crude steel production stood at 5.42 million tons in May 2020, a decline of 35% from the same month in the prior year. Capacity utilization was down as well, falling to 54.6% during the month. In May 2019, the utilization rate was 80.8% (Fig. 1).

However, production notched up from April 2020, increasing 1.9% from 5.32 million tons.

For comparison, global crude steel production fell 8.7% year over year to an estimated 164 million tons.

Estimated weekly production in June rose slightly, but steadily, during the month. Production stood at nearly 1.20 million tons in the first week of June and ended the month at 1.24 million tons, an increase of about 3.8% (Fig. 2).

**Imports and Exports —** The U.S. imported 2.78 million tons of steel in April 2020, a decrease of nearly 17% from the same month in 2019 (Fig. 3). However, imports were up from the prior month, increasing from 1.75 million tons.

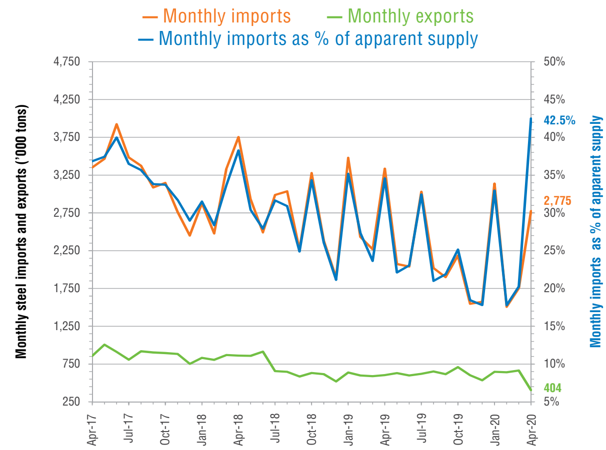


*Figure 3: U.S. imports and exports.* Source: U.S. Census Bureau.

Meanwhile, U.S. steel exports fell to 404,000 tons of mill products, a decline of 33% over the same month in 2019.

Table 1 provides a breakdown of imports by country of origin. In April 2020, imports of Chinese steel fell 57%

| Country/Region | Monthly imports ('000 tons) Apr'20 | Mar'20 | Apr'19 | m-o-m ('000 tons) | m-o-m (%) | y-o-y ('000 tons) | y-o-y (%) |
|---|---|---|---|---|---|---|---|
| Japan | 69 | 57 | 159 | 13 | 22.6 | (90) | (56.4) |
| South Korea | 161 | 206 | 275 | (45) | (21.6) | (114) | (41.4) |
| China | 28 | 19 | 64 | 8 | 42.8 | (37) | (57.1) |
| Taiwan | 48 | 61 | 72 | (13) | (21.8) | (24) | (33.0) |
| India | 11 | 16 | 14 | (5) | (31.8) | (3) | (23.8) |
| Turkey | 2 | 5 | 32 | (4) | (71.7) | (30) | (95.2) |
| EU | 244 | 300 | 376 | (56) | (18.7) | (133) | (35.3) |
| Russia | 1 | 1 | 1 | 0 | 27.6 | (0) | (14.7) |
| Brazil | 1,229 | 14 | 1,186 | 1,214 | 8,477.8 | 42 | 3.6 |
| Mexico | 383 | 272 | 277 | 111 | 40.7 | 106 | 38.4 |
| Canada | 337 | 536 | 371 | (198) | (37.0) | (34) | (9.2) |
| Other | 262 | 265 | 506 | (2) | (0.8) | (244) | (48.1) |
| **Total imports** | **2,775** | **1,752** | **3,335** | **1,023** | **58.4%** | **(560)** | **(16.8%)** |

***Table 1: U.S. imports by country/region.*** *Source: U.S. Census Bureau.*

| Steel products | Monthly imports ('000 tons) | | | m-o-m ('000 tons) | m-o-m (%) | y-o-y ('000 tons) | y-o-y (%) |
|---|---|---|---|---|---|---|---|
| | Apr'20 | Mar'20 | Apr'19 | | | | |
| Wire rod | 67 | 67 | 152 | 1 | 1.0 | (85) | (55.8) |
| Structurals | 37 | 26 | 51 | 11 | 41.1 | (14) | (28.1) |
| Bars | 201 | 180 | 206 | 21 | 11.4 | (5) | (2.6) |
| Rebar | 122 | 79 | 93 | 43 | 54.1 | 29 | 31.4 |
| Pipe and tube | 277 | 447 | 586 | (170) | (38.1) | (309) | (52.8) |
| Oil country tubular goods | 93 | 196 | 256 | (102) | (52.4) | (163) | (63.7) |
| Plates | 168 | 157 | 267 | 11 | 7.0 | (99) | (37.2) |
| Flat-rolled | 454 | 545 | 647 | (91) | (16.7) | (192) | (29.7) |
| Hot-rolled coil | 122 | 146 | 169 | (24) | (16.2) | (47) | (27.9) |
| Cold-rolled coil | 332 | 400 | 477 | (67) | (16.8) | (145) | (30.4) |
| Other finished | 107 | 91 | 132 | 16 | 17.5 | (25) | (19.2) |
| Finished imports | 1,310 | 1,513 | 2,041 | (202) | (13.4) | (731) | (35.8) |
| Ingots | 2 | 2 | 1 | (0) | (12.4) | 0 | 41.3 |
| Blooms, slabs, billets | 1,462 | 237 | 1,292 | 1,225 | 517.0 | 170 | 13.2 |
| Semi-finished imports | 1,464 | 239 | 1,294 | 1,225 | 512.7 | 171 | 13.2 |
| **Total imports** | **2,775** | **1,752** | **3,335** | **1,023** | **58.4%** | **(560)** | **(16.8%)** |

***Table 2: U.S. imports by product category.*** *Source: U.S. Census Bureau. Note: Monthly imports are rounded to the nearest integer.*

| Country | Currency per U.S. dollar | Monthly average exchange rate comparisons | | | m-o-m change | m-o-m (%) | y-o-y change | y-o-y (%) |
|---|---|---|---|---|---|---|---|---|
| | | Apr'20 | Mar'20 | Apr'19 | | | | |
| Japan | Yen/$ | 107.81 | 107.49 | 111.63 | 0.32 | 0.3 | (3.82) | (3.4) |
| South Korea | Won/$ | 1,224.46 | 1,220.30 | 1,142.21 | 4.16 | 0.3 | 82.25 | 7.2 |
| China | CNY/$ | 7.07 | 7.02 | 6.72 | 0.05 | 0.7 | 0.35 | 5.2 |
| Taiwan | TWD/$ | 30.08 | 30.12 | 30.06 | (0.04) | (0.1) | 0.02 | 0.1 |
| India | INR/$ | 76.24 | 74.35 | 69.43 | 1.89 | 2.5 | 6.81 | 9.8 |
| Turkey | TRY/$ | 6.85 | 6.34 | 5.76 | 0.51 | 8.0 | 1.09 | 18.9 |
| EU | €/$ | 0.92 | 0.91 | 0.89 | 0.01 | 1.1 | 0.03 | 3.4 |
| Russia | RUB/$ | 75.22 | 73.15 | 64.62 | 2.07 | 2.8 | 10.60 | 16.4 |
| Brazil | Real/$ | 5.33 | 4.93 | 3.90 | 0.40 | 8.1 | 1.43 | 36.7 |
| Mexico | MXN/$ | 24.10 | 22.14 | 18.94 | 1.96 | 8.9 | 5.16 | 27.2 |
| Canada | CAD/$ | 1.41 | 1.40 | 1.34 | 0.01 | 0.7 | 0.07 | 5.2 |

***Table 3: Monthly average exchange rate comparisons.*** *Sources: Organisation for Economic Co-operation and Development and X-Rates.*

year over year to 28,000 tons. Imports from Turkey were down, too, declining approximately 95% to 2,000 tons. EU imports fell as well, dropping 35% to 244,000 tons. However, imports from Canada and Mexico collectively grew 11% year over year to 720,000 tons.

Table 2 provides a breakdown of imports by selected products. The U.S. imported 1.46 million tons of semi-finished steel in April 2020, up 13% from the same month last year. However, finished steel imports declined during the same period, falling nearly 36% to 1.31 million tons. Of the finished products, imports of oil country tubular goods fell the hardest, declining nearly 64% to 93,000 tons. Wire rod imports were down, too, falling 56% to 67,000 tons. Hot-rolled coil tonnages also saw declines, dropping nearly 28% to 122,000 tons.

Table 3 provides an overview of the monthly average currency exchange rates to complement the data in Tables 1 and 2.

## U.S. Demand

**Automotive —** Three-month light vehicle sales in the U.S. (Fig. 4) fell 31.5% year over year, declining to 3.03 million units in June 2020. Single-month sales also were down, falling 25.2% year over year to 1.13 million units.

"The vehicle market shouldn't expect things to change much during the next quarter," said Charlie Chesbrough, senior economist at Cox Automotive. "Potential shortages on some

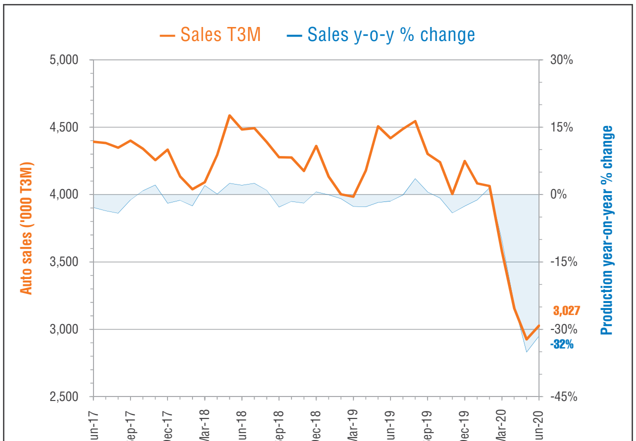


***Figure 4: U.S. automobile sales and year-on-year % change.*** *Source: WardsAuto.com.*

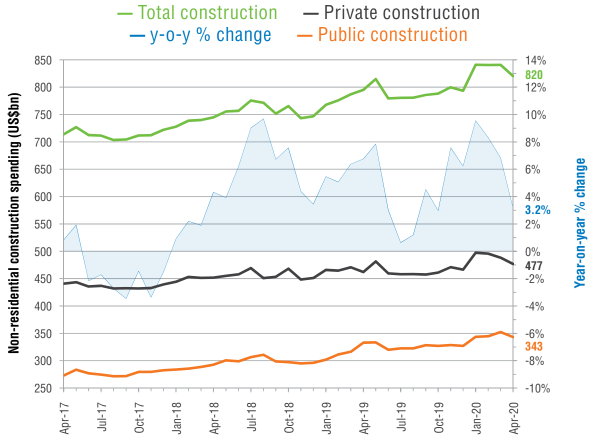


*Figure 5: Estimated value of construction put in place.*
*Source: U.S. Census Bureau.*

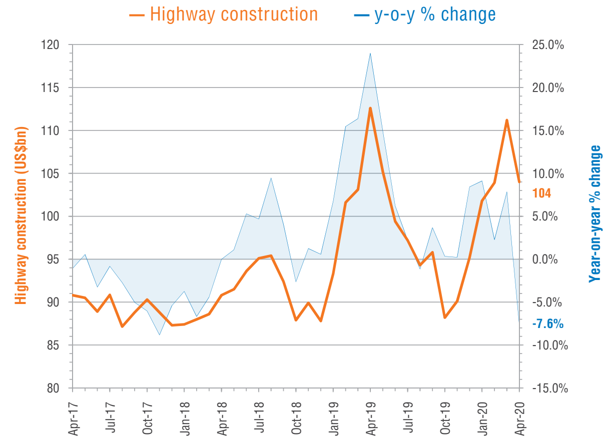


*Figure 6: Infrastructure spending.*
*Source: U.S. Census Bureau.*

products, a second wave of COVID-19 cases, and continued high unemployment will make Q3 challenging. However, we still believe the very worst of the crisis in terms of sales impact is behind us. The question for the rest of the year is the pace of the recovery, not the direction."

To be sure, there is much ground to recover.

According to LMC Automotive, the pandemic-related shutdowns wiped out an estimated 2.8 million units of planned production in the first half of the year. "Factoring in slower line speeds and reduced demand, full-year 2020 output is likely to be 3.4 million units lower than in 2019, a reduction of nearly 21%," it said.

**Non-Residential Construction —** Non-residential construction spending rose 3.2% year over year to a seasonally adjusted annualized rate of US$820.1 billion in April 2020 (Fig. 5). However, spending declined 2.5% from the prior month, dropping from US$840.8 billion.

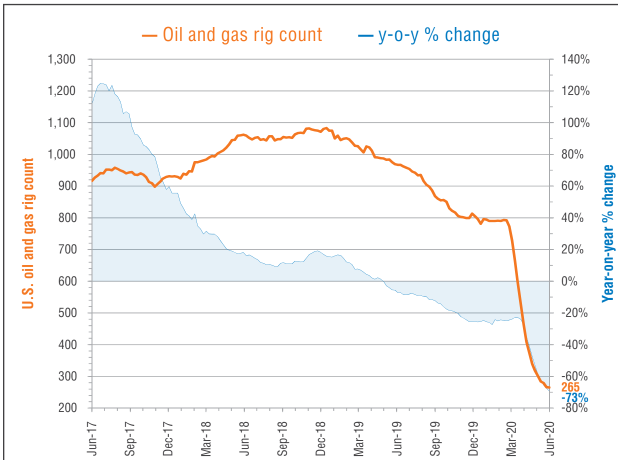


*Figure 7: U.S. oil and gas rig count.*
*Source: Baker Hughes.*

The spending data would seem to be a bright spot in an otherwise dark sky, but Anirban Basu, chief economist for the Associated Builders and Contractors, said the numbers aren't necessarily reassuring.

"Non-residential construction has fared far better than most economic segments during the COVID-19 crisis, but the industry's headline spending numbers fail to fully capture the damage inflicted on many key segments by the pandemic," Basu said.

"For instance, spending in the lodging category was down more than 12% in April relative to a year ago and down 11% in the amusement and recreation category. Spending is also down meaningfully in a number of categories that are public-sector-intensive, including education and highway/street."

Basu said that with state and local government finances now on shaky footing, infrastructure spending is in jeopardy. Future commercial projects are also imperiled, he said.

"Many office suites and storefronts have been vacated, which will suppress demand for new construction going forward. Capital will also be scarcer, resulting in greater difficulty securing financing for projects. Moreover, if the past is prologue, many dislocated construction workers will find jobs in other industries, given construction's tendency to be among the last economic segments to fully recover," he said.

**Infrastructure —** U.S. highway and street construction spending (Fig. 6) declined 7.6% in April 2020 to US$104 billion on a seasonally adjusted annualized basis. Spending also was down from the prior month, falling from US$111.2 billion.

**Energy —** The U.S. rig count plunged further during June, dropping to 265 units by month's end (Fig. 7). As of 26 June 2020, the count was down nearly 73% from the same week in the prior year.

According to the Reuters news service, some analysts are expecting that recent gains in oil prices will prompt drillers

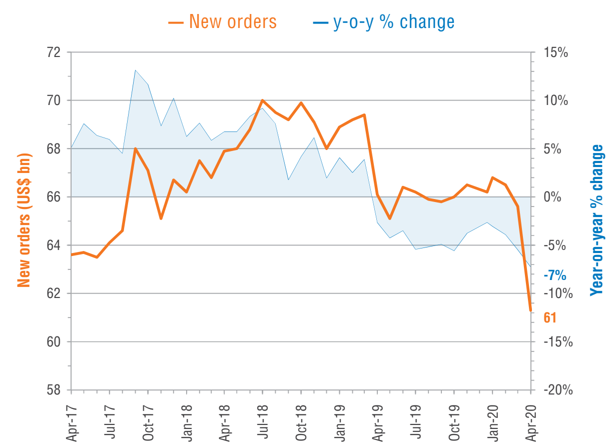


*Figure 8: Monthly non-defense capital goods.*
*Source: U.S. Census Bureau.*

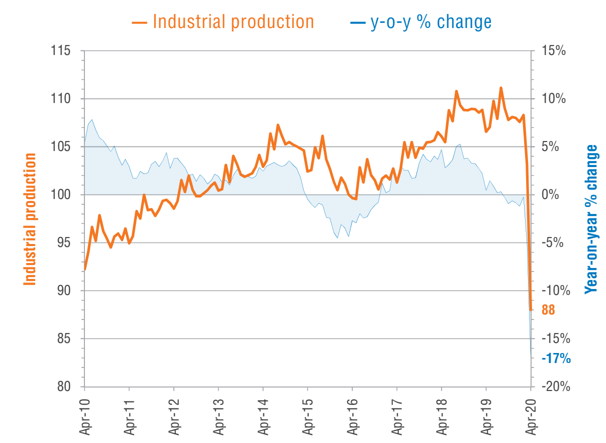


*Figure 9: Industrial production index.*
*Source: U.S. Federal Reserve Board.*

to slow the pace of rig reductions and possibly put some units back into service later in the year.

"While weekly declines have slowed a bit versus what we saw in April and May, they are likely to continue at the slower pace into the third quarter with most operators in no rush to pick up rigs and few others still cutting activity per their plans," U.S. financial services firm Tudor, Pickering, Holt & Co. wrote in a recent note, according to Reuters.

Non-Defense Capital Goods — New orders for non-defense capital goods, excluding aircraft and parts, declined 7.3% in April 2020, falling year over year to a seasonally adjusted US$61.3 billion (Fig. 8). Orders also declined from US$65.6 billion in the prior month.

Industrial Production Index — The industrial production index — a broad-based proxy for steel demand — fell to 88 points in April 2020, a decline of 17.4% from the same month in the prior year (Fig. 9). The score excludes the high-tech index. The score also was down from the prior month, falling from 103.2 points.

ISM Index — The U.S. manufacturing sector regained a bit of ground in May 2020, according to the Institute for Supply Management's monthly *Report on Business*. For the month, the institute's Purchasing Managers Index stood at 43.1% (Fig. 10), up from 41.5% in April. An index score above 50% indicates that the manufacturing sector is generally growing; a score below 50% indicates that it is generally contracting.

"May appears to be a transition month, as many panelists and their suppliers returned to work late in the month. However, demand remains uncertain, likely impacting inventories, customer inventories, employment, imports and backlog of orders," said Timothy R. Fiore, chairman of the institute's manufacturing business survey committee.

The institute said that of 18 manufacturing sectors surveyed as part of the monthly report, six reported growth.

## U.S. Pricing and Costs

Steel Prices — Average monthly prices for U.S. mill products (Fig. 11) generally moved upward in May 2020. For example, hot-rolled coil (HRC) prices notched up US$9/ton, or about 1.8%, from April 2020 to US$498/ton. Average cold-rolled coil prices also rose, increasing 3.9% from the prior month to US$661/ton. Plate prices were up, too, rising about 3% to US$588/ton.

More pricing data is shown in Table 4.

The difference between the average monthly HRC price in the U.S. and the European Union widened in May 2020 (Fig. 12). On a year-over-year basis, the spread grew to US$106/ton. In May 2019, the spread stood at US$57/ton. During the same period, the spread between the U.S. price and the average China price also expanded, increasing to US$101/ton. In 2019, the spread stood at US$96/ton.

Scrap Prices — Certain average monthly domestic scrap prices notched up in May 2020. The average price for

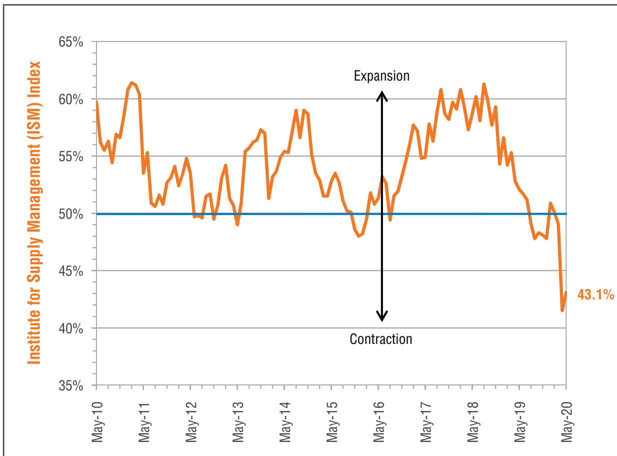


*Figure 10: ISM Manufacturing Purchasing Managers Index (PMI).*
*Source: Institute for Supply Management.*

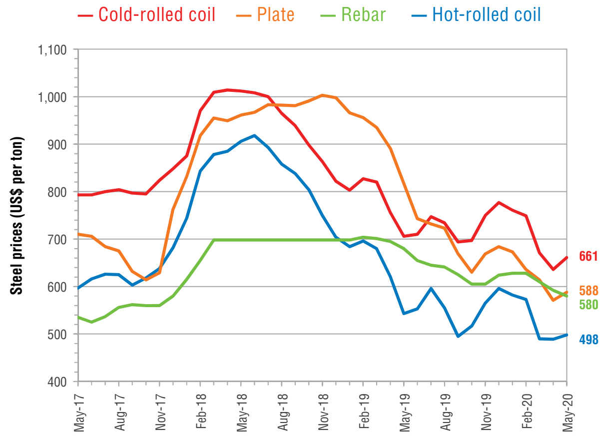


*Figure 11: U.S. steel prices.*
*Source: Platts.*

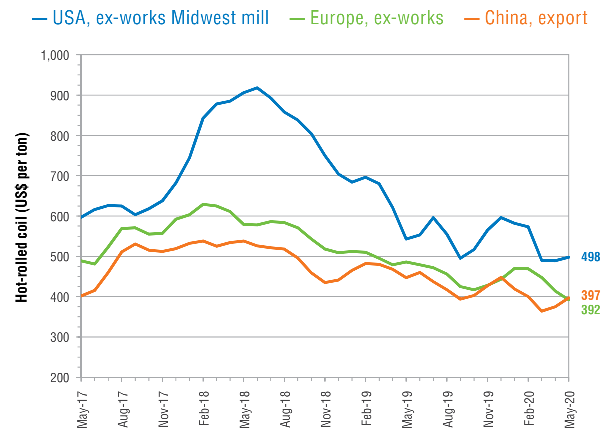


*Figure 12: U.S. prices compared to China and the EU.*
*Source: Platts.*

No. 1 heavy melt rose US$4/ton from the prior month to US$205/ton (Fig. 13). Meanwhile, average auto bundling prices increased US$10/ton from the prior month, rising to US$294/month. However, the average price for shredded scrap receded by US$2/ton, dropping to US$229/ton.

Certain U.S. metal spreads narrowed in May 2020. Based on average monthly prices, the difference between rebar and No. 1 heavy melt (Fig. 14) contracted, falling by US$16/ton to US$375/ton. The difference between hot-rolled coils and auto bundling also narrowed, decreasing by US$1/ton to US$204/ton. However, the difference between plate and No. 1 heavy melt grew month over month to US$383/ton, an increase of US$13/ton.

| Product | May'20 ($) | Apr'20 ($) | May'19 ($) | m-o-m ($) | m-o-m (%) | y-o-y ($) | y-o-y (%) |
|---|---|---|---|---|---|---|---|
| HRC | 498 | 489 | 543 | 9 | 1.8 | (45) | (8.3) |
| CRC | 661 | 636 | 706 | 25 | 3.9 | (45) | (6.4) |
| Galv | 717 | 703 | 788 | 14 | 2.0 | (71) | (9.0) |
| Plate | 588 | 571 | 817 | 17 | 3.0 | (229) | (28.0) |
| Wire rod | 597 | 614 | 744 | (17) | (2.8) | (147) | (19.8) |
| Rebar | 580 | 592 | 680 | (12) | (2.0) | (100) | (14.7) |
| Auto bundles/busheling | 294 | 284 | 268 | 10 | 3.5 | 26 | 9.7 |
| No. 1 HM | 205 | 201 | 209 | 4 | 2.0 | (4) | (1.9) |

***Table 4: Steel prices in U.S. dollars per ton by product category.*** *Source: Platts.*

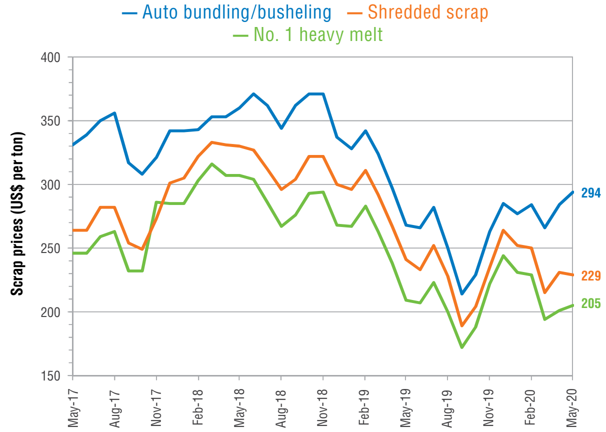


*Figure 13: U.S. scrap prices.*
*Source: Platts.*

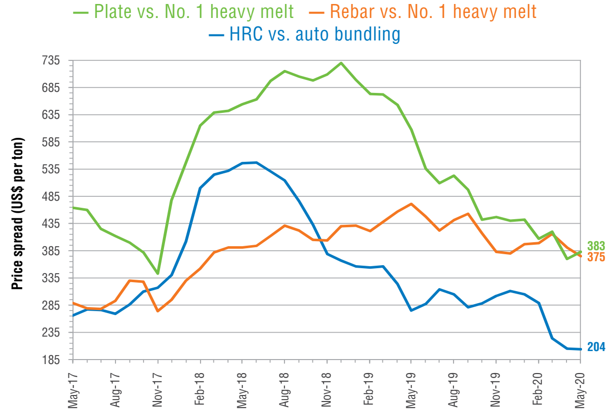


*Figure 14: Metal spread, HRC vs. auto bundles, rebar and plate vs. No. 1 heavy melt.*
*Source: Platts.*

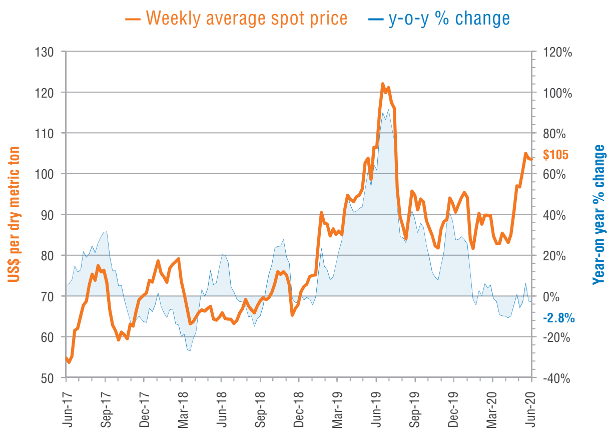


*Figure 15: Iron ore fines weekly average spot price (62% Fe content).*
*Source: Platts Iron Ore Index.*

## Global Pricing Benchmarks

Iron Ore Market — Weekly average spot prices for 62% iron ore (CFR China) held above the US$100/dry metric threshold during June, supported by healthy demand and supply disruptions.

According to the Platts Iron Ore Index, June's weekly average spot prices ranged from US$100.64/dmt to US$104.97/dmt (Fig. 15).

According to a quarterly report from Australia's Department of Industry, Science, Energy and Resources, weather issues and the COVID-19 pandemic have disrupted supply, and, at the same time, Chinese demand has remained strong through the pandemic.

"Chinese demand for iron ore has thus far proven to be relatively robust, despite the impact of COVID-19 and the shutdown of significant sectors of the Chinese manufacturing industry," the Australian government wrote in the report.

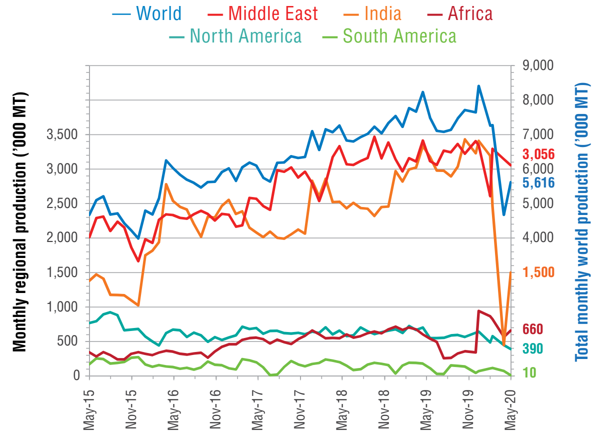


*Figure 16: DRI production by region.*
*Source: World Steel Association.*

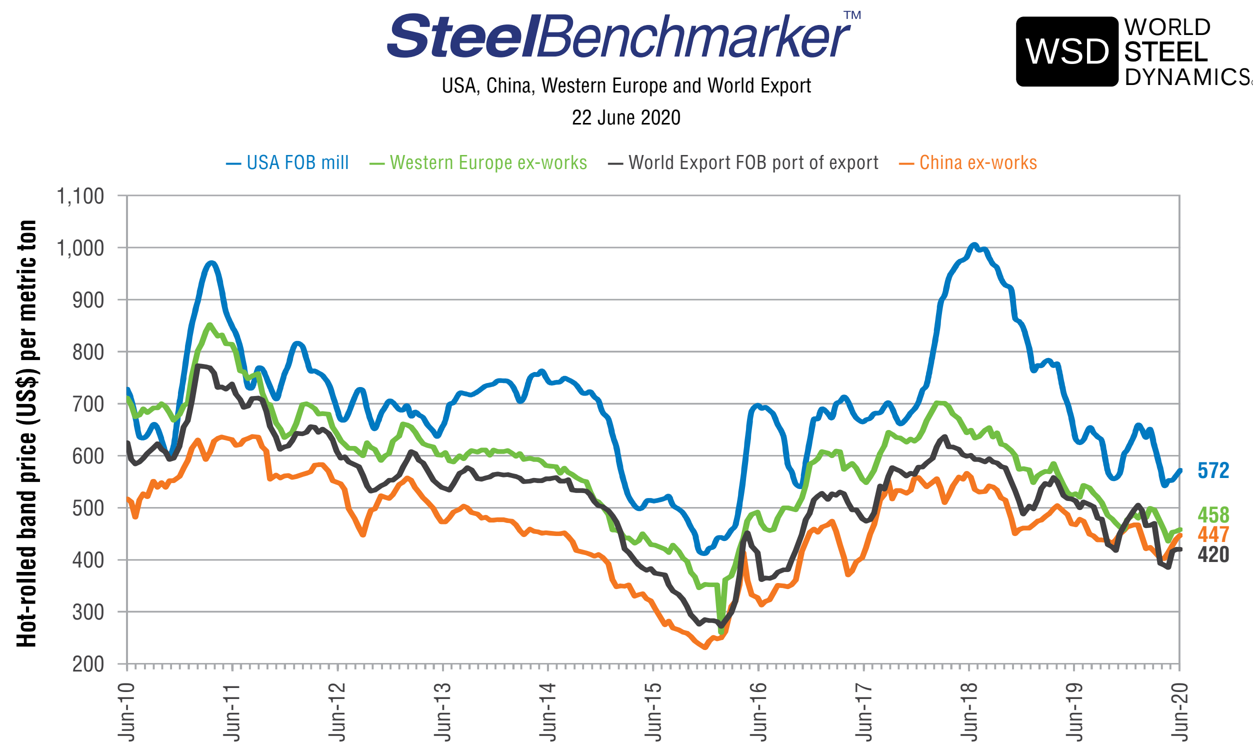


*Figure 17: SteelBenchmarker™ HRB price.*
*Source: World Steel Dynamics.*

"At this stage, it is not expected that Chinese demand will fall significantly, though the ongoing decline of consumer spending in OECD nations will increase the dependence of the Chinese steel industry on domestic stimulus measures."

Global DRI Production — On a year-over-year basis, global direct reduced iron (DRI) production fell 31.8% to an estimated 5.62 million metric tons in May 2020 (Fig. 16). During the same period, North American production declined 44.6% to 390,000 metric tons.

Hot-Rolled Band (HRB) Pricing — The U.S. benchmark price for hot-rolled band (Fig. 17) notched up during June, ending the month at its highest level since mid-April, according to World Steel Dynamics' SteelBenchmarker™.

According to the bi-monthly price assessment, the price as of 22 June stood at US$572/metric ton, the best since the week of 13 April, when it stood at US$577/metric ton.

For comparison, the world export on 22 June stood at US$420/metric ton, up 6.9% from mid-April. ✦

*Iron & Steel Technology* wishes to thank Platts, SteelBenchmarker™, The Steel Index and World Steel Dynamics for sourcing the data presented above. Information is compiled by Sam Kusic, AIST news editor.

Comments are welcome. Please send feedback to: industrystats@aist.org. Please include your full name, company name, mailing address and email in all correspondence.

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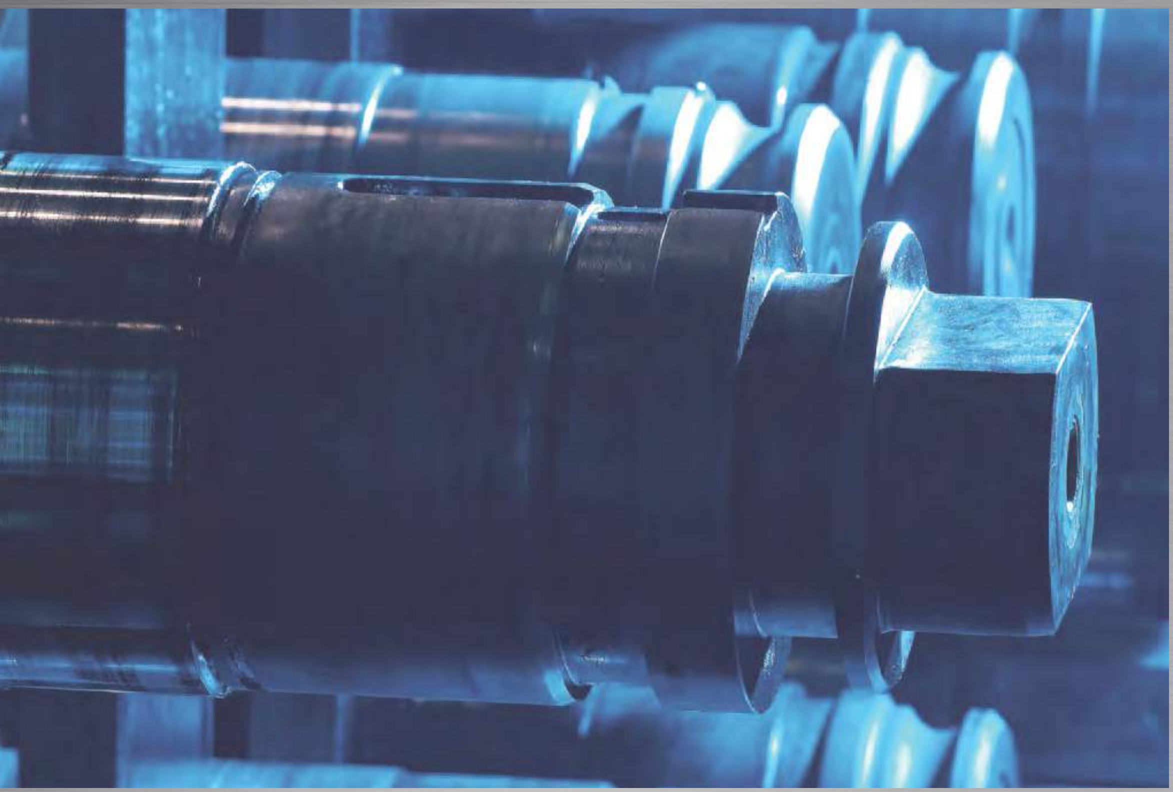


WORLD STEEL DYNAMICS is a leading steel information service in Englewood Cliffs, N.J., USA

WSD's steel experience, steel database and availability of steel statistics are the principles for performing steel forecasts, studies and analysis for international clients. WSD seeks to understand how the "pricing power" of steel companies the world over will be impacted by changes in the steel industry's structure. The views and opinions expressed in this article are solely those of World Steel Dynamics and not necessarily those of AIST.


## Authors

Peter Marcus (left)
managing partner,
World Steel Dynamics
pmarcus@worldsteeldynamics.com
+1.201.503.0902

John Villa (right)
research strategist,
World Steel Dynamics
jvilla@worldsteeldynamics.com
+1.201.503.0911


# Goodbye to steel cost inflation: Cost cuts, moderate wage boosts, lower raw material and energy prices

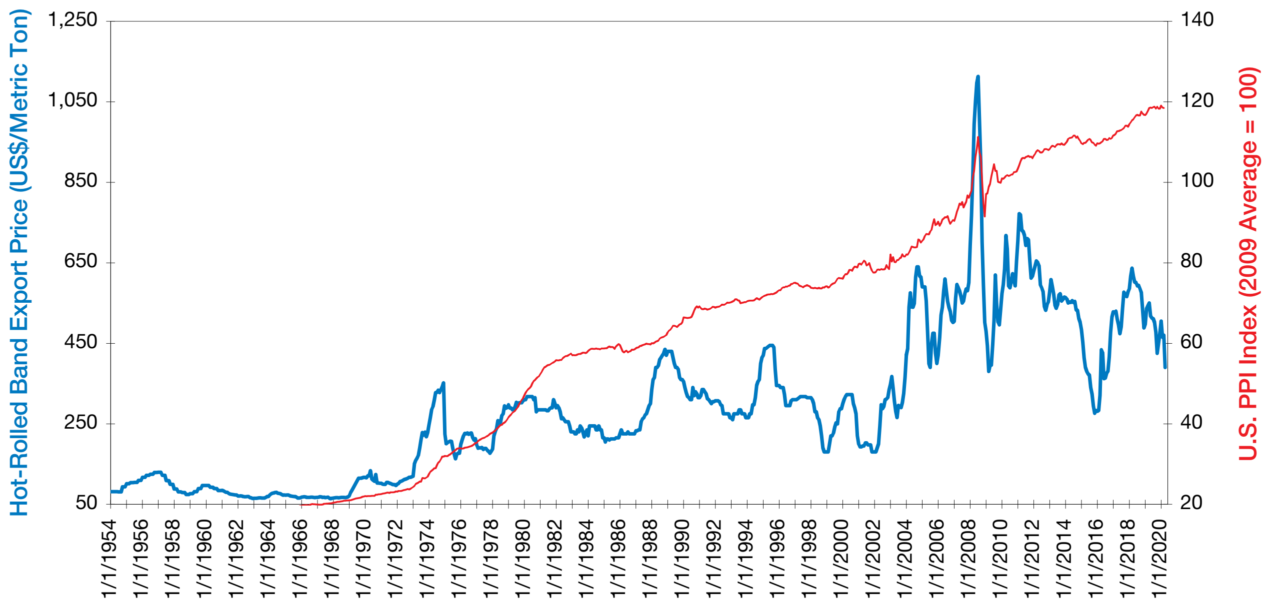
Steelmakers' cost to produce hot-rolled band (HRB) will continue to swing sharply over the steel cycle. However, in the next five years from the mid-point of one cycle to the next, WSD expects little to no steel mill cost inflation.

The mills' operating cost to produce hot-rolled band in the past 10 years has swung wildly — it's been a cost roller coaster. Based on WSD's monthly World Cost Curve results for the median-cost Chinese steel mill, the operating cost has ranged from a high of US$664/metric ton in September 2011 to a low of US$353/metric ton in January 2016 — for a variation of US$311/metric ton. For the median-cost non-Chinese mill, the high cost figure was US$710/metric ton in July 2011 and the low was US$367/metric ton in February 2016 — for a variation of US$353/metric ton.

Looking ahead to 2025, rather than no change in costs, some decline would also be no surprise.

- A sizable number of higher-cost plants will be either eliminated or downsized — especially during periods of shakeout in the industry such as the current one. Multi-plant companies, which are probably growing in number due to heightened M&A activity, will consolidate output at their most efficient units. In China, plant rationalization and company consolidation will be a major event. Baowu Group is seeking to double its size to about 200 million metric tons per year largely by acquisition. If iron ore prices remain high relative to steel scrap prices, more integrated steel plants will be shut down due to lack of cost competitiveness. Capital spending needs at integrated plants are especially huge. For example, the relining of a blast furnace may cost more than US$75 million and the replacement of aging coke ovens could cost US$300+ million.
- Labor costs per metric ton will rise only marginally. Man-hours/metric ton shipped by 2025 may be 5% lower given new labor-saving technologies. The rise in the worker wages may be just moderate because steelworkers, along with those in other manufacturing industries, are losing their negotiating power. As capital replaces labor (Karl Marx is turning over in his grave), workers are becoming increasingly replaceable.
- Iron ore prices delivered to China may drop significantly. For example, they are currently lofty relative to the world's leading iron ore producers' sinter feed cost delivered to the port of export — only about US$16/metric ton. More iron ore supply is coming into production in Australia, India, Russia and even Iran. Also, if the steel scrap price is as low as expected, a larger amount of it will be charged into basic oxygen furnaces (as an alternative to higher cost liquid pig iron). Chinese pig iron and steel production will be lower in a few years reflecting reduced demand in the country. (Note: If the international iron ore price drops sharply, China's domestic production of sinter feed and pellet, which is high cost, could fall 50% to roughly 125 million metric tons per year.)
- Coking coal in May 2020 was selling for only about US$112/metric ton, FOB Australia;

Figure 1




***World hot-rolled band export price vs. U.S. producer price index. Sources: SteelBenchmarker, WSD estimates, Reuters.***

hence, there's far less room for it to drop in price than iron ore. The price is at a level at which a number of non-Australian export-oriented coking coal mines can't long survive. A "wild card" that could tighten the supply/demand balance for this product would be further mandated closures in China of dangerous coal mines, due to their great depth and the emission of combustible gases. Also, highly polluting privately owned coke ovens in Shanxi Province may be further cut back.

- The price of obsolete steel scrap is forecast to be lower over the steel cycle in the next decade despite the rising global share of electric arc furnace (EAF) steel production. In China, the obsolete steel scrap reservoir, that's on average 10–40 years old, is forecast to rise to 318 million metric tons by 2030 versus 124 million metric tons in 2019. Growing direct reduced iron capacity and increased pig iron offerings on the world market at times will exert downside pressures on steel scrap prices.
- Expenses to meet additional air and water pollution mandates through 2025, and perhaps to 2030, may not rise significantly for those plants already meeting the mandated standards. However, beyond 2030, a number of steel mills will begin to take actions to achieve zero carbon emissions by 2050. (Note: Integrated steel plants emit about 2 metric tons of $CO_2$/metric ton of steel production, versus about 0.5 metric tons for EAF-based units. For most integrated plants, the achievement of zero carbon emissions would entail huge capital outlays in order to re-orient the plant's steelmaking processes — to the hot briquetted iron/EAF route rather than the blast furnace/basic oxygen furnace route. Also, a separate facility to produce hydrogen might be needed. Besides the capital costs, the rise in operating cost could be US$50–100/metric ton.)
- The purchase price of energy in different forms, including electricity and fuel oil, may be reduced. Because of oversupply, the Brent oil price may not recover to US$50/barrel versus the May 2020 figure of US$25/barrel. The average price in 2019 was US$64/barrel.

As seen in the figure, the export price for HRB has risen far less than the U.S.'s producer price index (PPI). Since its peak in 1989, the HRB export price is about unchanged, while the PPI is up about one-third.

This report includes forward-looking statements that are based on current expectations about future events and are subject to uncertainties and factors relating to operations and the business environment, all of which are difficult to predict. Although WSD believes that the expectations reflected in its forward-looking statements are reasonable, they can be affected by inaccurate assumptions made or by known or unknown risks and uncertainties, including, among other things, changes in prices, shifts in demand, variations in supply, movements in international currency, developments in technology, actions by governments and/or other factors. ✦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Personnel Spotlight is a free service featuring news of recent appointments, promotions, retirements and obituaries relevant to the steel industry. To submit material for consideration, please email a press release and high-resolution photo(s) to jemling@aist.org.

## Bull Moose Tube Co.

**Andy Annakin** has been appointed executive vice president and chief commercial officer of tubular products manufacturer Bull Moose Tube Co.

Annakin has held distinctive positions across sales, marketing and purchasing during his 30+ year career, including vice president of sales and marketing for CMC Impact Metals and director of plate sales for Olympic Steel.

Annakin earned an M.B.A. in finance and marketing and a B.S. degree in business economics from Indiana University.

## Companhia Siderúrgica Nacional


Noldin

Brazilian steelmaker Companhia Siderúrgica Nacional (CSN) has hired **Jose Noldin** as their new general manager — product development. Noldin returns to his home country after nearly a decade in Belgium, where he held leadership positions with global lime supplier Lhoist in innovation, new business development and strategic projects for the steel business segment.

Noldin has received several industry awards, including the 2017 Thomas Medal and Prize from the Iron and Steel Society (U.K.) and the 2014 Ironmaker of the Year Award from the Brazilian Metallurgy, Materials and Mining Association (ABM). He also has many best paper awards for his contributions in the fields of iron ore, ironmaking and sustainability.

A member of AIST since 2002, Noldin has been active in the Ironmaking, Direct Reduced Iron and Oxygen Steelmaking Technology Committees. For his service to AIST, he was honored with an AIST Presidential Citation in 2015.

Noldin holds a B.S. degree in mechanical engineering from the Federal University of Santa Catarina in Florianopolis, Brazil, and an M.S. and Ph.D in metallurgical engineering from the Catholic University of Rio de Janeiro.

## Worthington Industries


Rose


McConnell

The board of directors of Worthington Industries Inc. announced that **B. Andrew (Andy) Rose,** the company's president, will become president and chief executive officer (CEO), effective 1 September 2020, succeeding long-time chairman and CEO **John P. McConnell,** who will remain with the company as executive chairman.

As executive chairman, McConnell will continue to work with Rose, the executive team and the board to develop company strategy and help identify value-enhancing strategic initiatives including acquisitions, joint ventures and strategically important relationships.

Rose was named president of Worthington in 2018. He joined the company in 2008 as vice president and chief financial officer. In 2014, he was promoted to executive vice president and chief financial officer (CFO) and has been instrumental in advancing the company's financial and capital allocation strategies. Before joining Worthington, Rose was a senior investment professional of a public investment company and partner and co-founder of Peachtree Equity Partners, a private equity fund backed by Goldman Sachs.

McConnell began his career at Worthington in 1975 as a general laborer, later working in sales and operations with increasing responsibility. He served as corporate personnel director and was instrumental in administering the company's highly recognized employee-based policies. He was appointed vice president and general manager of the company's largest steel facility in Columbus, Ohio, USA, in 1985.

A member of Worthington's board of directors since 1990, McConnell became vice chairman in 1992 and was named CEO in March 1993. In September 1996, he was named chairman of the board.

## Associations

### American Iron and Steel Institute (AISI)

Brett

The American Iron and Steel Institute (AISI) has appointed **John Brett,** president and CEO of ArcelorMittal USA, as chairman of the board of directors for the 2020–2021 term. Brett has been serving as interim chairman since mid-March after the retirement of previous chairman **Roger Newport,** former chief executive of AK Steel.

Brett was named vice president of ArcelorMittal and CEO of ArcelorMittal USA in January 2016. Previously, Brett served as executive vice president of finance, planning and procurement for ArcelorMittal USA. In this capacity, he had responsibility for the planning, directing, managing and controlling of the U.S. business's financial, purchasing and supply chain management activities.

Brett joined predecessor company Inland Steel Co. in 1988 as an associate accountant and held various leadership positions in accounting, finance and supply chain management. He is a graduate of DePauw University with a degree in economics. Brett also earned an M.B.A. in finance and accounting from the University of Chicago.

Dempsey

In additional news, the AISI board of directors elected **Kevin Dempsey** as interim president and CEO to succeed **Thomas J. Gibson,** who announced his retirement in March.

Dempsey, who has served as AISI's senior vice president for public policy and general counsel since 2009, assumed his new role on 23 June 2020. Gibson will serve as an advisor to AISI during the transition.

Before joining AISI, Dempsey was a partner at Dewey & LeBoeuf, a global law firm, and its predecessor Dewey Ballantine LLP. While in private practice, Dempsey litigated numerous international trade cases on behalf of U.S. steel producers and other U.S. industries before the U.S. International Trade Commission, the U.S. Department of Commerce and the U.S. courts. Prior to joining Dewey Ballantine in 1995, Dempsey served as counsel to Sen. John C. Danforth (R-MO) and the U.S. Senate Committee on Commerce, Science and Transportation.

Dempsey received his J.D. degree from Harvard Law School and a B.A. degree in history from Washington University. He is a member of the District of Columbia bar and is admitted to practice before the U.S. Court of International Trade and the U.S. Courts of Appeals for the Federal Circuit and the D.C. Circuit.

## Obituaries

Gantz

**Joseph E. Gantz** passed away on 20 June 2020 at the age of 90. Born in Williamsport, Pa., USA, and formerly of Lebanon, Pa., Gantz was U.S. Navy veteran and achieved his B.S. degree in metallurgy from The Pennsylvania State University. He was employed with United States Steel Corporation for 30 years in various management positions and also with Chemalloy Chemical Corp. as both a supervisor and consultant.

Gantz was a 49-year Life Member of AIST, having joined in 1971. He belonged to the Philadelphia Member Chapter.

Gantz is preceded in death by his wife Janet. He leaves behind three children, Evon, Amy and Jeannine; five grandchildren; and one great-grandchild.

VanBibber

**Michael VanBibber,** 52, of South Fayette, Pa., USA, passed away on 3 July 2020 after a one-year battle with glioblastoma brain cancer.

VanBibber was raised in Pleasant Hills, Pa., outside of Pittsburgh. He earned a degree in mechanical engineering from Virginia Tech in 1990. Following graduation, he moved back to the Pittsburgh area and spent his career working in the steel industry.

VanBibber worked for Weirton Steel, SMS Demag and, most recently, TMEIC. Highlights from his career include a work rotation in Germany where he and his family lived and traveled to countries around Europe and experienced the culture. He published several papers and was also awarded a U.S. patent for a method of and device for mounting and functional verification of roll fittings, which is used all over the world and in 20 sites in the U.S.

VanBibber joined AIST in 1999 and was actively involved in the Cold Sheet Rolling Technology Committee (CSRTC) and the Pittsburgh Member Chapter. He served as golf chair for the Pittsburgh Member Chapter from 2013 to 2016 and chair of the CSRTC from 2016 to 2017. VanBibber was a member of the AISTech Conference Planning Committee from 2015 to 2018, including a term as Exhibitor Chair for AISTech 2017 in Nashville, Tenn., USA.

VanBibber is survived by his wife Michelle; son Tyler; daughter Helina; father Larry; brothers Jeff and David; four nephews; and one niece. ✦

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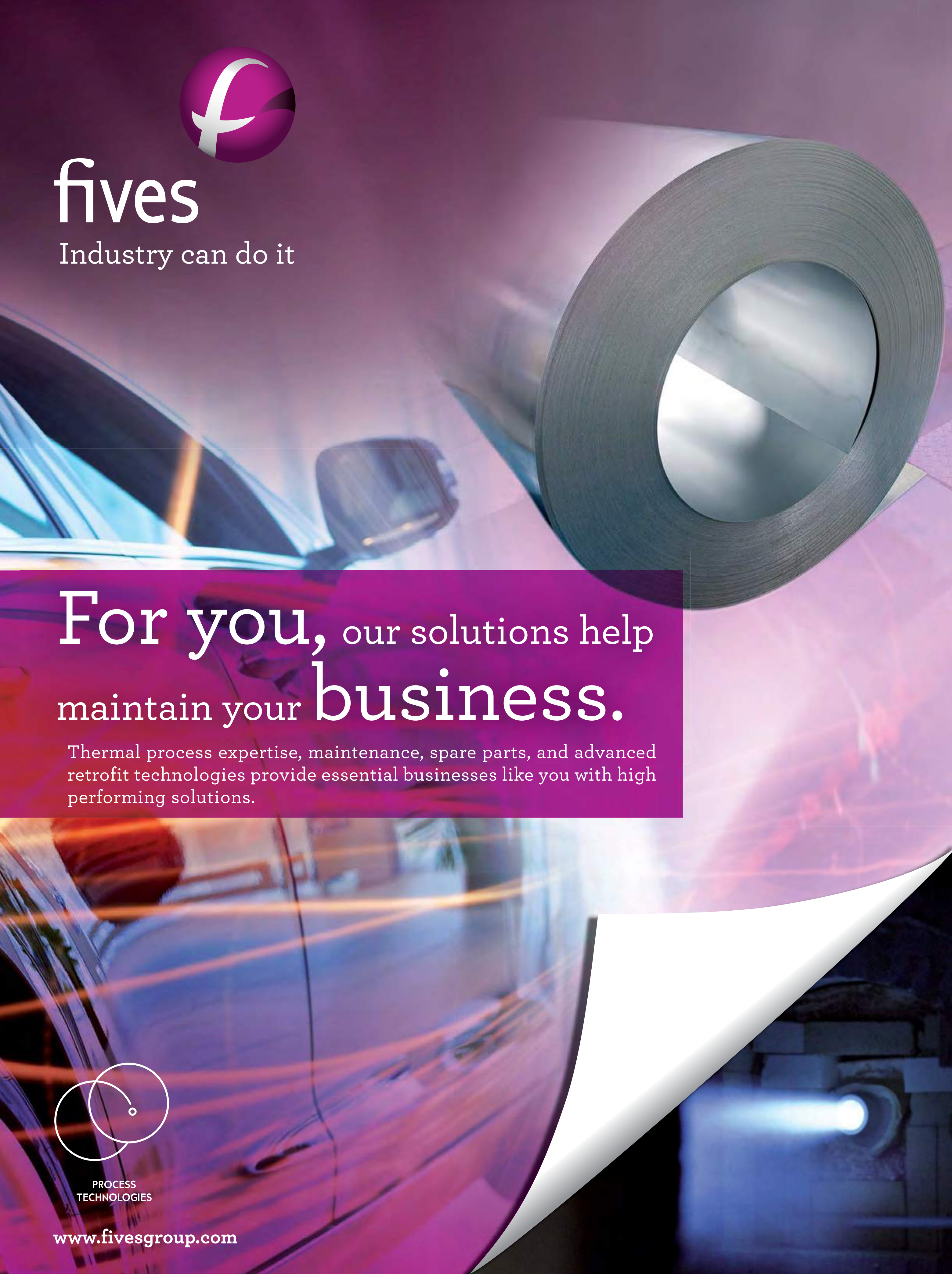
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# Keeping Critical Spaces Clean Using Room Pressurization With Self-Maintaining Air Cleaners

Hazards are ever-present in the steel plant environment, and a heightened awareness and emphasis on safety is a necessary priority for our industry. This monthly column, coordinated by members of the AIST Safety & Health Technology Committee, focuses on procedures and practices to promote a safe working environment for everyone.

Author

Josh Longmire
sales manager — clean air systems, The Systems Group, Jonesboro, Ark., USA
jlongmire@tsg.bz

Comments are welcome. If you have questions about this topic or other safety issues, please contact safetyfirst@aist.org. Please include your full name, company name, mailing address and email in all correspondence.

Room pressurization is used in many industries to prevent dust or other materials from entering critical spaces. Hospitals, laboratories and pharmaceutical manufacturers often use this method to maintain their clean rooms. In steel mills, employee health and safety, along with protecting equipment, are constant concerns when dealing with dust in this type of environment. In this article, health and equipment issues that are normally created by dust in a steel mill environment will be discussed as well as how positive pressurization can be used with a specific type of filtration to fix this problem.

There are many lung-related health hazards that are caused by breathing metal dust, and there are several costly equipment failures caused by metal dust. While most steel mills use heating, ventilation and air conditioning (HVAC) systems to attempt to keep these areas clean, this is inefficient and ineffective because these types of filters are not able to catch all of the dust particles. When these filters have dust on them it increases the static pressure resistance on the HVAC system and can reduce the amount of room pressurization.

By using positive pressure from a self-maintaining air cleaner, these spaces can be kept clean at a much lower cost and with better results. Positive pressure inside a room is effective in preventing dust from entering the room, and the use of a self-maintaining air cleaner provides effective filtration while creating the positive pressure environment.

## Dust Hazards in the Steel Mill

Electric arc furnaces (EAFs) in steel mills produce dust made up of a variety of metals and other materials. Many of these materials are harmful to human health. These dusts present a health risk to anyone who has to work in areas such as operator pulpits where dust levels are high. In enclosed spaces like transformer vaults, motor control center rooms or other electrical rooms, conductive metal dusts can cause an arc flash hazard. All critical spaces require an extra level of protection from harmful dusts.

## Health Risks From Steel Mill Dust

Steel mills produce metal dust that contains a mixture of large and small particles. The exact components of the dust depends on the type of steel and the process. In general, the most common metal found in steel mill dust is iron, followed by carbon, lime, zinc, manganese, calcium and silicon, but the dust often includes metals such as lead, arsenic and cobalt, which are highly toxic.[1] Gerdau Long Steel North America's material safety data sheet for steel mill EAF dust warns that inhalation can cause allergic reactions, cancer, lung damage, weakness, personality changes, kidney damage and problems with the brain and nervous system.[2]

The health hazards of all these materials are well known and the U.S. Occupational Safety and Health Administration (OSHA) has set limits on acceptable time-weighted exposures. However, employers and inspectors often measure these exposures in workers who are directly exposed to the fumes and material from the EAF. They may not measure the chronic exposure caused by long-term work in rooms full of accumulated dust. Metal dust particles can be as small as 0.3 micron and besides being easily inhaled, it can get on a worker's hands, into their clothes and onto their food. The health risks of daily long-term exposure to accumulated dust in the workspace may not be measured accurately.

In many areas of the steel mill, workers may not be exposed to harmful levels of this dust. However, in areas like control rooms, pulpits or other enclosed workspaces exposed to large amounts of dust, exposure can be heavy. Dust that accumulates in these enclosed spaces can be hard to remove, and an ordinary HVAC system is not designed to handle a heavy load of metal dust. The amount of dust and particulate produced by arc furnaces and other steel mill processes is far in excess of what a typical HVAC filter is meant to deal with.

A typical HVAC filter is designed to capture particles sized at 3–10 microns with 20% efficiency (MERV 5). A self-maintaining air cleaner filter is designed to capture particles size at 0.30 micron with 99.999% efficiency (MERV 15). All filters are rated by the minimum efficiency reporting value (MERV) rating standard set forth by the American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE).

The MERV rating system is a value that indicates the size of particles an air filter is designed to capture. Higher MERV ratings are more effective at capturing smaller particles. That's why hospitals tend to use MERV 16 or higher, so the most pollutants possible can be captured. The ASHRAE designed the MERV rating and advises the use of filters with minimum MERV ratings of 6. The U.S. Department of Energy recommends a minimum of MERV 13.

- MERV 1 to 4 — Less than 20% of particles (>10 microns) are captured.
- MERV 5 to 8 — Less than 20%–60% of particles (3–10 microns) are captured.
- MERV 9 to 12 — 40%–85% of particles (1–3 microns) are captured.
- MERV 13 to 16 — 70%–98% of particles (0.30–1.0 micron) are captured.
- MERV 17 to 20 — Even the smallest particles (<0.3 micron) are captured.

Workers in enclosed areas such as operator pulpits with insufficient dust control are at risk of lung diseases such as siderosis, silicosis, black lung and lung cancer from inhaling dust throughout the workday. They are also at risk of neurological damage from lead and manganese. These conditions become worse with heavier or longer exposure, and they can be permanent. Because of these health risks, it's important to keep dust out of these workspaces. It's common for HVAC filters to be used for this purpose, but they will often fail within a matter of days and need to be replaced. These filters also may not be efficient enough to capture the small particles of metal dust, and the smallest particles are the most dangerous because they are inhaled the most deeply into the lungs. While high-efficiency particulate air (HEPA) filters can capture these small particles, they also often fail within a few weeks or months from the volume of dust being filtered through them.

In addition to the health risks of this dust, it also creates an unpleasant and difficult working environment. Dust throughout a workspace can get into expensive equipment like computers, clog HVAC vents, and get all over the clothes, tools and equipment used by the workers. This accumulation of dust is not only unpleasant but can make it more difficult for workers to do their jobs. In a room without positive pressure, someone opening a door might sweep in a cloud of dust with their entry, so that over time the

## Table 1

*Section of Material Safety Data Sheet for Steel Mill Electric Arc Furnace Dust*[2]

| CAS # | Component | Percent |
|---|---|---|
| 1309-37-1 | Iron oxide | 0–35 |
| 1305-78-8 | Calcium oxide | 0–35 |
| 1314-13-2 | Zinc oxide | 0–25 |
| 14464-46-1 | Silica, cristobalite | 0–15 |
| 7439-96-5 | Manganese | 5–10 |
| 1309-48-4 | Magnesium oxide fume | 5–10 |
| 7440-31-5 | Tin | 0–5 |
| 1344-28-1 | Aluminum oxide | 0–5 |
| 7440-47-3 | Chromium | 0–5 |
| 1314-56-3 | Phosphorus pentoxide | 0–5 |
| 7446-09-5 | Sulfur dioxide | 0–5 |
| 7789-75-5 | Calcium fluoride ($CaF_2$) | 0–5 |
| 7782-41-4 | Fluorine | 0–5 |
| 7489-98-7 | Molybdenum | 0–5 |
| 7440-22-4 | Silver | 0–5 |
| 1314-62-1 | Vanadium pentoxide | 0–5 |
| 7440-38-2 | Arsenic | 0–5 |

**Table 2**

*ANSI/ASHRAE MERV Standard 52.2-2012*

| MERV Std. 52.2 | Intended Dust Spot Efficiency Std. 52.1 (2) | Average arrestance | Particle size ranges | Typical applications | Typical filter type |
|---|---|---|---|---|---|
| 1–4 | <20% | 60–80% | >10.0 µm | • Residential/minimum<br>• Light commercial/minimum<br>• Minimum equipment protection | • Permanent/self charging (passive)<br>• Washable/metal, foam/synthetics<br>• Disposable panels<br>• Fiberglass/synthetics |
| 5–8 | <20–60% | 80–95% | 3.0–10.0 µm | • Industrial workplaces<br>• Commercial<br>• Better/residential<br>• Paint booth/finishing | • Pleated filters<br>• Extended surface filters<br>• Media panel filters |
| 9–12 | 40–85% | >90–98% | 1.0–3.0 µm | • Superior/residential<br>• Better/industrial workplaces<br>• Better/commercial buildings | • Non-supported/pocket filter/rigid box<br>• Rigid cell/cartridge<br>• V-cells |
| 13–16 | 70–98% | >95–99% | 0.3–1.0 µm | • Smoke removal<br>• General surgery<br>• Hospitals and health care<br>• Superior/commercial buildings | • Rigid cell/cartridge<br>• Rigid box/non-supported/pocket filter<br>• V-cells |
| MERV Std. 52.2 | Efficiency | | | Typical applications | Typical filter type |
| 17–20[1]<br>*Deleted from ASHRAE* | 99.97%–99.9999% | | | • Hospital surgery suites<br>• Clean rooms<br>• Hazardous biological contaminants<br>• Nuclear material | • HEPA<br>• ULPA |

Note: This table is intended to be a general guide to filter use and does not address specific applications or individual filter performance in a given application. Refer to manufacturer test results for additional information.

(1) ASHRAE does not have a test procedure for HEPA testing and has thus dropped the MERV 17–20 classifications.

(2) ANSI/ASHRAE 52.1 ranges are provided for reference only. The NSI/ASHRAE 52.1 Standard was discontinued as of January 2009.

accumulation becomes more and more problematic and costly to clean up.

## Arc Flash Risks From Steel Mill Dust in Motor Control Center Rooms

Steel mills contain many types of electrical equipment that could act as ignition sources when surrounded by conductive metal dust. A few examples are transformer vaults and motor control centers, which need to be protected from conductive metal dust entering the room. Sparks from electrical equipment can ignite accumulated dust and create arc flash hazards.

In addition to the risk of electrical equipment causing arc flash hazards and threatening the lives of the personnel around them, there is also a threat of destroying expensive equipment and the cost associated with the downtime due to such an event. Valuable equipment could be damaged and, in the worst-case scenario, lives could be lost.

With the presence of large electrical equipment like transformer vaults, there is high potential for an electrical spark to ignite any dust that has accumulated in the room. Transformers especially involve very large amounts of electricity with significant potential to act as an ignition source. Also, these types of rooms tend to be very large and, therefore, difficult to clean once dust has been allowed to accumulate. The best solution is to prevent dust from entering the rooms at all.

As indicated in Table 3, the National Fire Protection Association (NFPA) recommends that if dust has accumulated to one to two times the threshold for allowable dust accumulation, it should be cleaned up within 8 hours on easily accessible surfaces and within 24 hours on hard-to-reach surfaces. If the accumulated amount is greater than four times the allowable amount, it must be cleaned up within one hour of reaching that amount. These numbers

## Table 3

*National Fire Protection Association (NFPA) 484 Maximum Time for Cleanup of Metal Dust*[3]

| Accumulation on the worst single square meter of surface | Longest time to complete unscheduled local cleaning of floor-accessible surfaces | Longest time to complete unscheduled cleaning of remote surfaces |
|---|---|---|
| >1 to 2 times threshold dust mass/accumulation | 8 hours | 24 hours |
| >2 to 4 times threshold dust mass/accumulation | 4 hours | 12 hours |
| >4 times threshold dust mass/accumulation | 1 hour | 3 hours |

assume that the facility is clean, and that the accumulation is caused by a leak or sudden release of dust. By NFPA standards, a facility should never have a long-term consistent accumulation of dust at or above the threshold limit.[3]

Unfortunately, in many facilities, dust can accumulate at possibly dangerous levels for years, not hours. In Fig. 1, dust is present on the floor, but the dust inside or under the panels is not seen. In a room like a motor control center room or a transformer room, just a spark from an electrical source could create an arc flash. As shown in Fig. 1, accumulation of dust on the floor in this space is a problem, but it seems likely that the exposed floor is still cleaned more often than under, on top of, or behind the equipment, where the accumulation could have reached dangerous levels.

## Positive Pressure as a Solution to Dust Issues in Critical Spaces

### What Does It Mean to Create Positive Pressure in a Space?

— Positive pressure simply means that the pressure inside the space is greater than the pressure outside. For this to be accomplished, the space must be enclosed well enough that the increased volume of air will stay inside. Doors opening and closing should not create significant pressure loss, but doors or windows cannot be left open. For positive pressure in a room to be effective, the pressure must be maintained, and if the pressure is allowed to drop, dust will start entering the space again.

All HVAC and other airflow systems are designed for a certain number of air changes, which is how often the air in that space is replaced by clean air. For areas in a steel mill or other metal manufacturing facilities, the number of air changes per hour may be anywhere between 10 and 20, depending on how heavy the air contamination is.[4] The appropriate number of air changes is determined by what is required to maintain clean air.

$$q = nV \quad \text{(Eq. 1)}$$

where

$q$ = fresh air supply ($ft^3/h$, $m^3/h$),
$n$ = air change rate ($h^{-1}$) and
$V$ = volume of room ($ft^3$, $m^3$).

The formula shown in Eq. 1 allows system designers to calculate how much airflow is necessary to create enough air changes per hour for the space and the level of air contamination. This usually leads to replacing the same volume of air that is removed, leading to neutral pressure. Under neutral pressure, air can flow freely in either direction, in or out of the room, carrying dust and particulate with it.

Positive pressure is achieved by having more air flowing into the room than the amount of air being removed from the room. This creates a pressure differential between the inside and outside spaces. Differential pressure in settings like steel mills is recommended to be no less than 0.02 inch of water gauge

## Figure 1

*Dust accumulation in a motor control center.*

and preferably higher.[5] This is achieved by developing a system that will add more air to the room than the air that is being removed. In most settings, both the removed air and the return air are filtered to remove contaminants and dust.

Because airflows from areas of higher pressure to lower pressure, the positive pressure inside a space will be constantly pushing back against contaminated air and dust that might enter the space. With air trying to flow out of the high-pressure area, it will create a flow outward every time a door is opened, or through any openings in the room.

## Purpose of Positive Pressurizing a Room

Positive room pressure is frequently used in hospitals and other medical settings where contamination of clean space could be a problem. Laboratories and pharmaceutical manufacturers also commonly use this technique to maintain clean space where contamination from outside must be avoided.

Figure 2

*Standard HVAC filtering motor control center.*

This concept can be applied to steel mills and the critical spaces that need to be kept as free of dust as possible. Rooms in a steel mill don't need to be as clean as a hospital room, but a hospital atmosphere will not put nearly as much strain on the filtration system as the air in a steel mill. Keeping a room under positive pressure keeps dust from entering. Whenever a door is opened, air will try to flow outward, pushing back against dirty air that might flow in.

Positive pressure to prevent dust from entering a room is a much easier solution than trying to keep it clean with housekeeping measures. In an environment like a steel mill, keeping critical spaces as clean as they need to be would require constant dust cleanup. Not only is this a waste of time and resources, but also might leave dust accumulated in hard-to-reach but common places like overhead beams or ceiling tiles. Positive pressure greatly reduces or eliminates the need for cleaning because it keeps dust from entering. It also decreases the health risks to employees and the potential for dust hazards.

## Equipment for Creating Positive Pressure

Many facilities create positive pressure using an HVAC system with standard filters that are typically rated as MERV 5. For medical or laboratory facilities, HEPA filters that are rated as MERV 17–20 are also used for their very high filtration efficiency. This type of system, however, is not ideal for use in a steel mill. The airborne dust load in a steel mill is far higher than would be found in those settings. Standard HVAC filters are not designed to deal with this type of dust load. They will quickly become overwhelmed with dust and will start to block airflow through the system as well as allowing smaller dust particles through the filters, as illustrated in Fig. 2.

It is common for the HVAC filters to require changing once a week or even once a day. Besides the expense of constant filter changes, steel mills also must deal with the time and labor required to change these filters, as well as the cost of disposal since the filters may contain hazardous materials.

## Self-Maintaining Air Cleaners

One solution to this problem has recently been developed: the self-maintaining air cleaner. Instead of HVAC or HEPA filters, these dust collectors use round cartridge filters that hang vertically from a tube sheet. These systems are called "self-maintaining" because the filters are cleaned by pulses of compressed air. As a result, they do not require manual cleaning. The filters meet the recommended efficiency of MERV 155, which means they are efficient for particles as small as 0.3 micron.

Fig. 3 shows the pulse jets above the filters. These jets pulse compressed air through the filters, keeping them functioning and maintenance-free for much longer than other types of filtration systems. Many steel mills using these systems for positive pressure areas can see filter life of one year or more. Unlike HEPA filters, the cartridge-style filters are designed for heavier dust load applications.

These systems serve two functions. First, they filter the dust out of the air through the MERV 15 cartridge filters, removing dust and contaminants. Second, they provide clean, filtered air to the room. While they do this, the fans add enough air to create positive pressure inside the room. Common locations for self-maintaining air systems include transformer vaults, motor control centers, server rooms, hydraulic rooms, operator control pulpits, compressor rooms and reactor vaults.

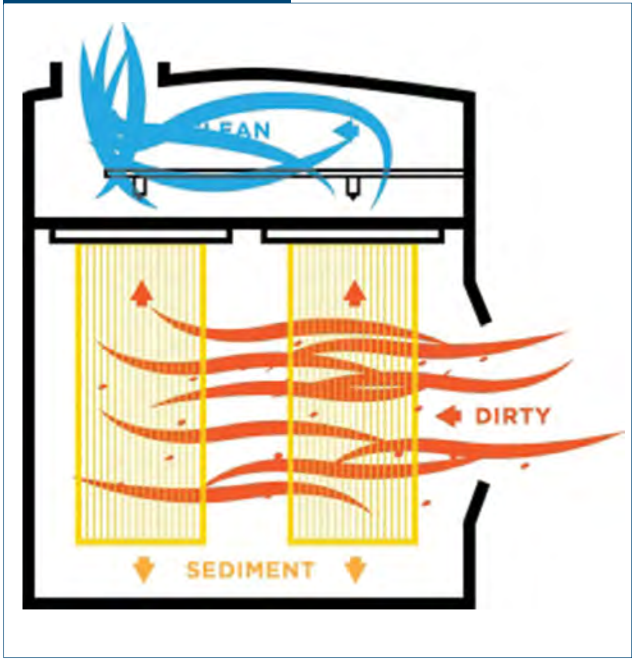
A system of this type is illustrated in Fig. 4. The drums beneath the air cleaner collect dust, which is then disposed of. The filters are accessed through a door for replacement. Also shown is the air inlet, which takes in ambient air from outside into the air cleaner to be filtered. As seen in this photo, these self-maintaining air cleaners can be placed in a variety of locations. This one creates positive pressure inside a transformer vault. It is rated for approximately 16,000 cubic feet per minute with a fan operating at 7 inches of water column, resulting in a 3.8-to-1 air-to-cloth ratio. It has 12 cartridge-style filters.

Depending upon the size of the space and the number of air changes per hour required, self-maintaining air cleaners can be designed in a variety of sizes. Another option is the choice between constant airflow and a variable frequency drive. The variable frequency drive is connected to a sensor that detects loss of pressure in the room, such as when the door is opened. This signals the fan to increase the airflow. With constant airflow, the room will still maintain positive pressure, although it may not return to full pressure as quickly after a loss.

The main advantage to using a self-maintaining air cleaner is the greatly decreased requirement for maintenance and filter changes. Unlike an HVAC system, these systems are designed for heavy dust loads, whether they are filtering air from outside or from inside the facility. HEPA filters in these applications tend to become quickly clogged with dust, but when they are used as secondary filters in a self-maintaining air cleaner system, the MERV 15 filters capture most dust and the HEPA secondary filters may last years instead of months.

The same equipment that functions as a self-maintaining air cleaner, taking in ambient air for room pressurization, can also serve as a more standard dust collector, taking dirty air from inside the facility and filtering it before venting or returning it. To maintain positive pressure with this type of use, ambient air will have to be added back into the building along with the filtered air in order to maintain positive pressure.

Figure 3




*Internal view of a self-maintaining air cleaner.*

Figure 4

*Self-maintaining air cleaner installed on exterior of steel mill.*

## Conclusion

Steel mills are challenging environments for dust control. Equipment such as EAFs produce large amounts of dust, and this dust can be hazardous to worker health and equipment. Critical spaces in steel mills must be kept free of dust. These spaces include those that contain critical equipment and electronics, such as transformer vaults, motor control centers, etc. They also include spaces such as control pulpits where steel mill personnel are present. The most effective solution to keeping these spaces clean is to keep them under positive pressure.

While HVAC filters are often used for filtration in these settings, a more efficient and effective method is the use of a self-maintaining air cleaner system. This type of system is able to create positive pressure in critical spaces while also increasing filter life and decreasing maintenance cost and time. The positive pressure created by the system prevents dust from entering the room and maintains a clean space.

## References


1. Rizescu, C.Z.; Backinschi, Z.; Stoian, E.V.; and Poinescu, A.A.,"Characterization of Steel Mill Electric Arc Furnace Dust," *Journal of Hazardous Materials*, Vol. 109, Nos. 1–3, June 2004, pp. 59–70.
2. Gerdau Long Steel North America, "Material Safety Data Sheet, Material Name: Steel Mill Electric Arc Furnace Dust," 2013.
3. Engineering Toolbox, "Air Change Rates in Typical Rooms and Buildings," 2005, www.engineeringtoolbox.com/air-change-rate-room-d_867.html.
4. Noll, J.; Cecala, A.; and Hummer, J., "Instituting a Filtration/Pressurization System to Reduce Dust Concentrations in a Control Room at a Mineral Processing Plant," *Mining Engineering*, Vol. 67, No. 12, December 2015, pp. 42–48. ✦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# World’s Longest Suspension Bridge Will Connect Europe and Asia

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This monthly column features “Our Stories” from worldsteel, covering automotive, construction and building, infrastructure, and innovation.

Editor

Desmond Hinton-Beales
editor, Specialist – The Content Marketing Agency, Bristol, U.K.
desmond.hinton-beales@specialistuk.com

Scheduled to open in 2023, the Canakkale 1915 bridge will be a steel-built infrastructure first, spanning the Dardanelles strait that separates the European and Asian continents.

As the Turkish government undertakes an ambitious infrastructure investment program, parts of the country are being transformed by new megatunnels and bridges. The Canakkale 1915 bridge is one such project, conceived to open as a tribute to mark 100 years of the modern Turkish republic.

The northwestern region of Turkey functions as an important connection between Europe and Asia, with ground traffic currently funneling through the narrow stretch of land surrounding Istanbul which leads on to the borders of Greece and Bulgaria.

Turkey’s rising economic growth as a result of agricultural expansion, increased transit links and the country’s growing popularity as a tourist destination, has led to serious congestion around its major cities.

The growing struggle facing the existing transport system has caused the government to announce its Vision 2023 program, which aims to boost capacity across road, rail and sea networks.

## A Towering Achievement

The suspension bridge is being constructed in the northwestern Turkish province of Canakkale and will service the 320-km-long Kınalı-Tekirdağ-Çanakkale-Balıkesir motorway which will connect the Anatolian peninsula and East Thrace once completed. Currently, this journey requires a 30-minute ferry ride, but once the bridge is in place this will be reduced to a short drive of just 10 minutes.

*With the span between its two towers sitting at 2,023 m, the Canakkale 1915 is set to become the world’s longest suspension bridge.*

With the span between its two towers sitting at 2,023 m, the Canakkale 1915 is set to become the world's longest suspension bridge, outstripping Japan's Akashi Kaiky bridge by 32 m. Its full length, including the approach viaducts, will stretch to 4,608 m.

Formed of a reinforced concrete deck, the bridge structure supporting the road surface will be underpinned by a pair of shear-connected longitudinal steel box beams. These will in turn be interconnected by steel crossbeams that sit on external cantilevers.

The 45-m-wide deck is expected to handle large amounts of commercial and private traffic, with three lanes moving in both directions and maintenance walkways on either side, contributing significantly to the socioeconomic development of the region.

The towers, which sit on a pair of steel platforms each mounted just above sea level on massive 65,000-metric-ton submerged caissons, will make the bridge the fourth tallest in the world, with its striking design stretching 318 m into the sky.

## A Partnership Forged in Steel

Once completed, the Canakkale bridge will have 128,000 metric tons of steel deployed in its construction, a mammoth undertaking for a single company.

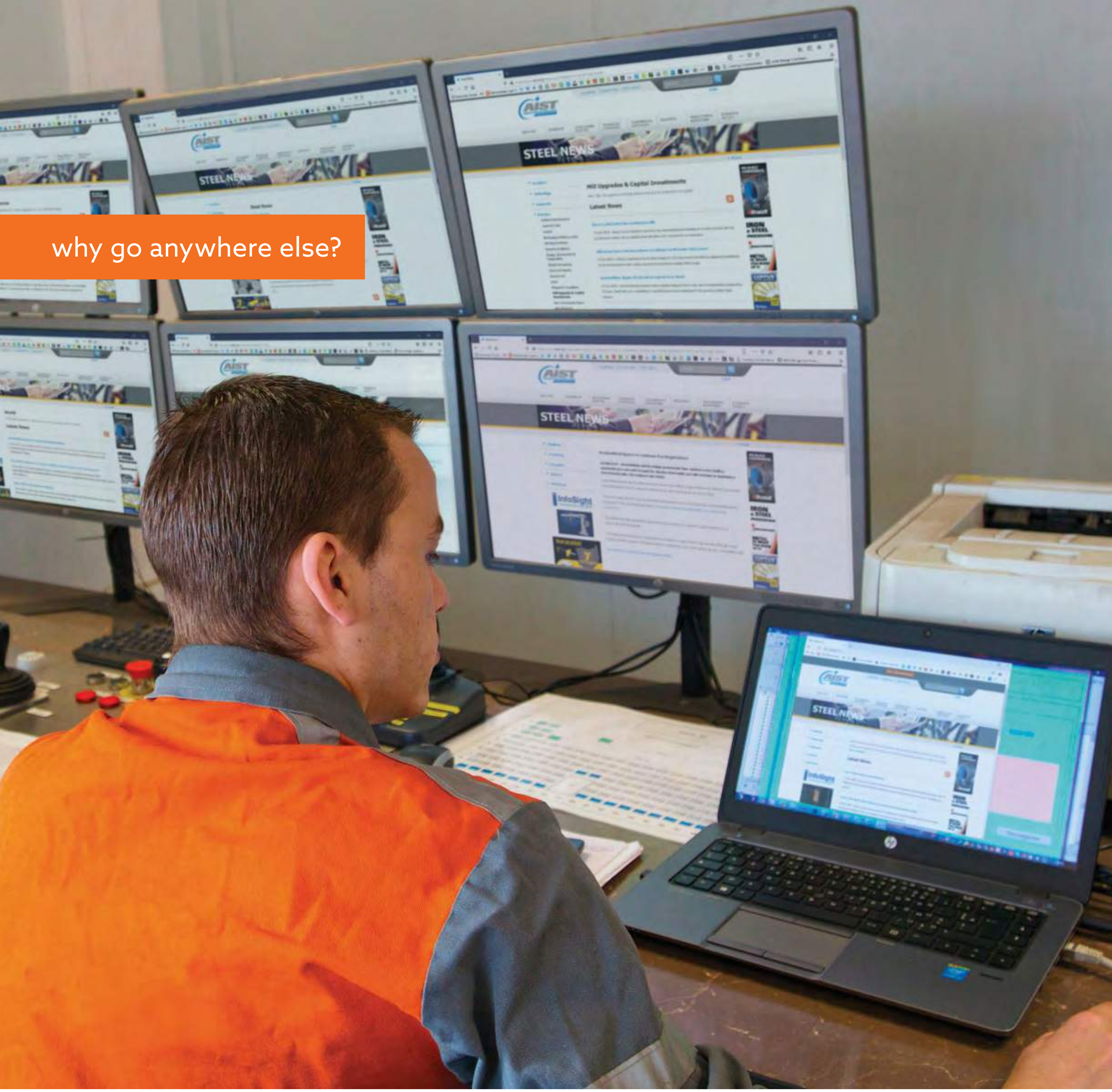
As such, the steel elements of the bridge represent a partnership between Turkish and South Korean suppliers, with Turkey's Çimtaş and South Korea's POSCO agreeing to supply 35,000 metric tons of heavy steel plate for the tower structures, cabling systems and road surface.

The partnership is also supplying 52,000 metric tons of steel plate for the bridge deck and 41,000 metric tons of steel wire rods for the suspension system.

The Canakkale is being run as a "design-build" project. Typically for bridge construction, the design is completed before contractors and suppliers are selected. For this project, however, construction and design take place concurrently, requiring coordination between the architect and contractors from very early on.

A US$3 billion investment, this record-breaking, steel-built suspension bridge is set to be transformative for the region's transport systems, with socioeconomic effects for Turkey and eastern Europe.

This and other stories are available at stories.worldsteel.org. ✦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# Improving Periodic Defect Detection in Hot-Rolled Long Products by Means of Combination Between Eddy Current and Vision

Digital technologies are transforming industry at all levels. Steel has the opportunity to lead all heavy industries as an early adopter of specific digital technologies to improve our sustainability and competitiveness. This column is part of AIST's strategy to become the epicenter for steel's digital transformation, by providing a variety of platforms to showcase and disseminate Industry 4.0 knowledge specific for steel manufacturing, from big-picture concepts to specific processes.


## Authors

Bruno Chedal-Anglay (left)
director, Steel Process Product Development (SPPD) Consulting, Normandy, France
brunochedal@gmail.com

Jose Ignacio Lucas Fuentes (right)
sales manager, ISEND, Valladolid, Spain
sales.manager@isend.es

Jose Ignacio Díaz
research and development, ISEND, Valladolid, Spain
rd.main@isend.es


Periodic defect roller marks (PDRM) (Fig. 1) are still an important problem for hot-rolled long products, affecting all grades; among them is the high-margin engineering steel production with specific lower T° rolling conditions, increasing roll crack occurrences due to fatigue stress. Most PDRMs are caused by groove cracks (GCs). An early detection of GCs as well as their identification is of paramount importance to improve the profitability of steel plants, and in many cases their survival. This paper will discuss the benefits of a new solution called EDDYeyes, synchronizing eddy current (EC) testing and Vision in real time. This is a complex solution that includes digital EC signals acquisition with on-time treatment and high-speed Vision systems, with high-quality LED lighting and complex math algorithms to give faster and more accurate defect information.

## Discussion

**The Problem Identification —** Periodic defects caused by roll marks are one of the rolling mill's biggest issues. A broken roll generates periodic defects until it has been fixed and will affect every delivery to customers. The on-time PDRM detection has a direct impact on the income statement of the rolling mill because all defective coils must be sold at lower prices and delivered to less profitable customers. To be effective, defects must be quickly confirmed and the guilty roller identified.

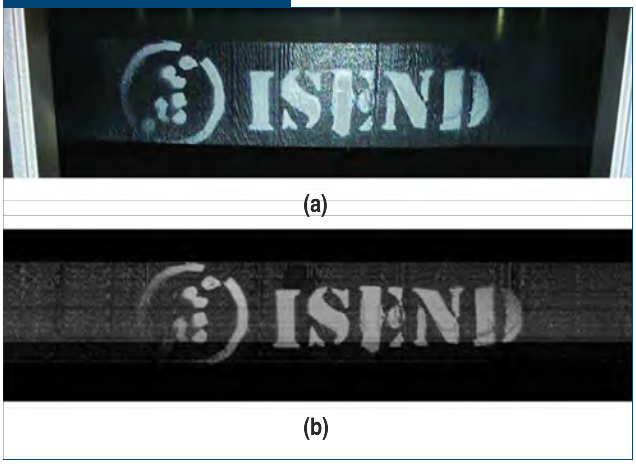
Until now, several methods have been used for the detection and confirmation of PDRM, among which the most prominent are eddy current[1] and artificial Vision, used separately. In both cases, there are deficiencies. EC is very reliable, but it isn't intuitive, and it usually requires a delay of more than 1 hour for visual recognition. On the other hand, artificial Vision is intuitive, but it is often not reliable due to harsh environmental conditions such as steam, dirt, water, etc., and can't ensure optimal images. In both cases, the necessary investigation time is a real loss. However, the evolution of technologies allows a new approach to improve dramatically the PDRM early detection.

**The Ideal Solution —** The ideal solution would combine the benefits of eddy current with those of the image. For this, it should be as reliable as the first and as intuitive as the second. Examples of both

Figure 1

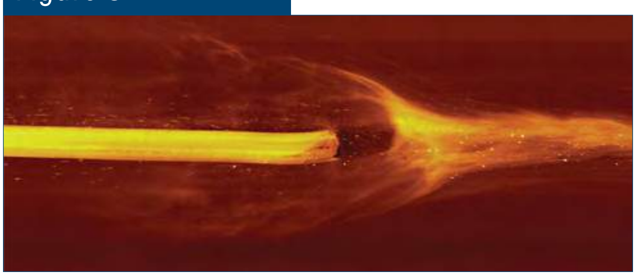

*Picture of periodic defect roller marks (PDRM) taken from EDDYeyes.*

Figure 2




*Vision comparison between static picture (a) and an EDDYeyes picture simulation at 99 m/second (b).*

Figure 3



*Wire rod nose during hot rolling process at 99 m/second.*

methodologies in a reasonable and logical way were already explained[2] with an application for the final user.

A new family of solutions has recently been introduced in the aluminum and steel industries, synchronizing EC as a primary detector with artificial Vision as a confirmation element as well as a secondary detector. This makes it possible to detect periodic defects early and drastically reduces investigation time. Additionally, this technology allows discrimination between random-type surface defects (scab, rolling scabs, overlaps, overfill, etc.) from those due to GCs, which produce repetitive surface defects.

**An Innovative and Proven Solution —** EDDYeyes technology is the result of the ISEND's work in this field.[2] The key factor is not separately adding eddy current technology and Vision but synchronization of both tools based on production parameters.

This technique consists of integration in real time and with a high degree of accuracy between the signal coming from the eddy currents and an artificial Vision system that captures images of all the signals potentially due to defects. The greatest difficulty is the synchronization of both elements and their process in a very short time, by using artificial intelligence algorithms, so that any alarm can be immediately verified visually even if the alarms is under the threshold set up by the users. As a result, good-quality images carry out the surface defect confirmation.

Both technologies used separately are present in various ways in the market, but the integration between the two is achieved for the first time with EDDYeyes, since it is not a simple integration between systems, but a whole development that optimizes the results and therefore should be considered as a single system. EDDYeyes has been developed in the most demanding conditions, with wire rod rolling at temperatures at 1,100°C and 110 m/second speed with vibrations.

The development has been carried out taking account as a test element the 5.5-mm wire rod produced at 110 m/second, the most demanding conditions in comparison with bigger sizes and speeds.

To develop EDDYeyes, it was necessary at first to use a workbench able to reach speeds of 100 m/second (Fig. 2), and in a second step a real installation in rolling mill customer facilities (Fig. 3).

During the development, multiple tests were carried out that have subsequently been confirmed in real environments.

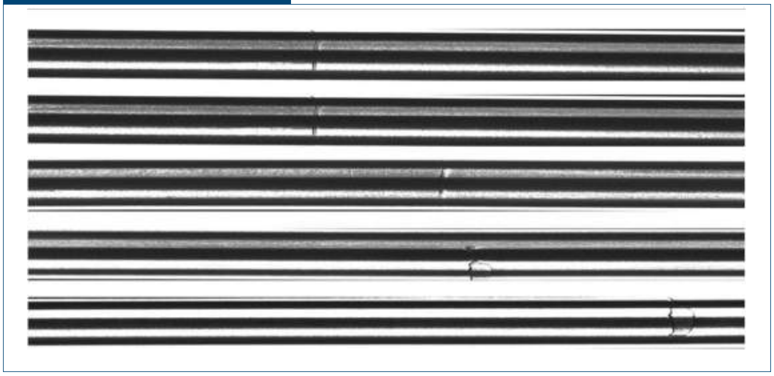
**Three Improvement Areas —** The three major areas of improvement this method provides in the detection of PDRM are:

- Early confirmation of periodic defects that occur before the defect violates the alarms configured in the standard eddy current system for short defects.
- Immediate identification of the roll causing the defect.
- PDRM identification of defects that are not detectable by eddy currents (Fig. 4).

Figure 4

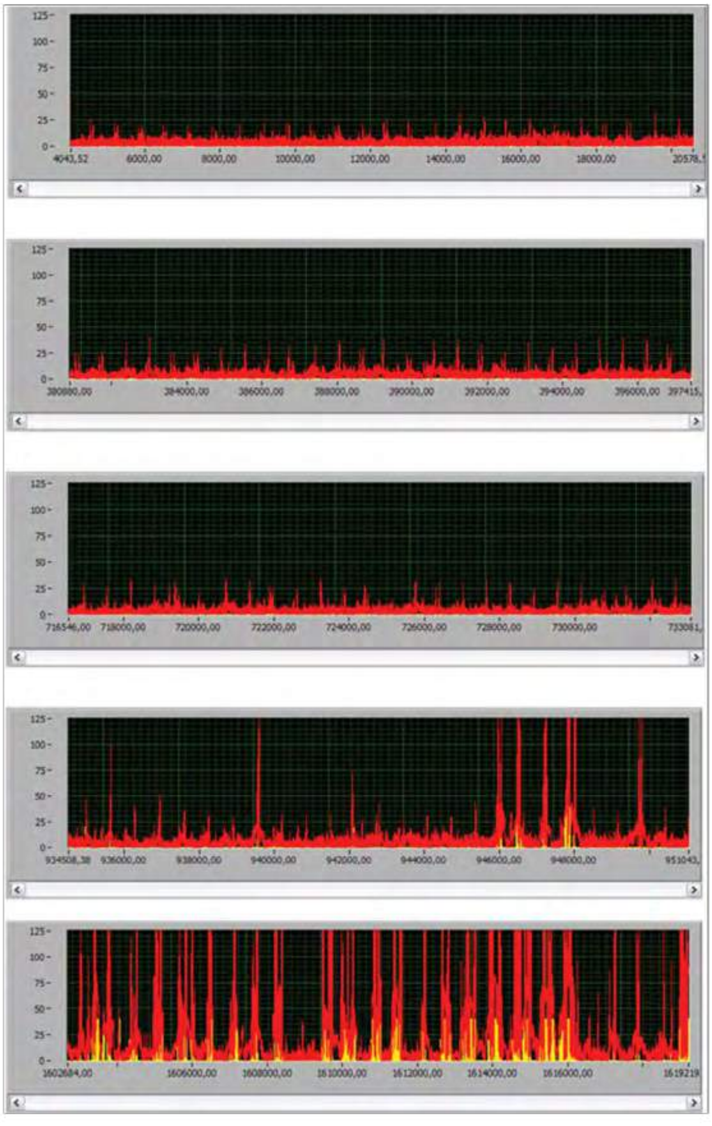
*A typical roller crack defect.*

Figure 5



*Evolution of a PDRM.*

Figure 6



*Eddy current amplitude evolution.*

Early Detection of PDRM — During the rolling process, the roller with GC starts with small empty slots that evolve and grows larger and larger (Fig. 5). Once the deteriorated groove begins to mark the material, these marks will be enlarging, achieving a size that will make them detectable by the eddy current technology. With artificial intelligence algorithms, peaks of amplitude can be detected that obey a certain frequency, even when EC signals are below the threshold of noise or off the alarm set by the users.

These algorithms allow for an order to be launched in the artificial Vision system to take and save images with that frequency and present the user with the real image on the screen, being able to decide when the rolling mill must be checked for cleaning, repair or replacement options.

In an analogous way, and using algorithms, the roll that is producing the mark can be determined with a good approximation.

Identification of Periodic Defects Not Detectable by the Eddy Current System — The artificial Vision system is not limited to being a mere confirmation element, but taking advantage of its potential, it acts as a second detector for those surface defects that, due to their morphology, do not produce appreciable signals due to EC. Again, using mathematical algorithms, periodic patterns can be obtained that may be due to potential defects. In a similar methodology to the previous section, whenever a periodic signal appears, the system will notify an alarm and present to the operator the images of the area of the material where it is produced.

PDRM Investigations Without Vision — In this situation, it is necessary to wait for the combined size/thermal signatures' signals from groove cracks for an indeterminate number of coils before confirming that a PDRM is present.

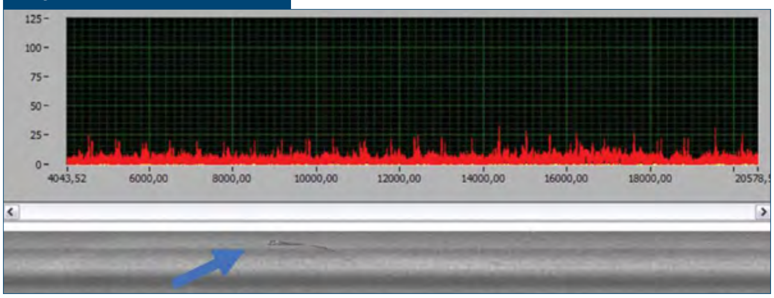
With the traditional eddy current solution, the analysis must be performed by graphics provided by the equipment. As a consequence with a 2.5-metric-ton coil per produced every 2 minutes, many defective coils will be rolled: 20 mn ⇔ 25 mT ⇔ one truckload. Fig. 6 shows four different stages of graphs that represent the peak amplitude evolution (Table 1). At the

## Table 1

*Eddy Current Alarm Log*

| Time | ID | Batch ID | Coil Sequence | Diameter | Mat ID | Pulses | Alarm | Roll ID | Level | PD alarm |
|---|---|---|---|---|---|---|---|---|---|---|
| 15:10 | XXXX58 | 4 | 26 | 21 | ***BCR | 92 | F = 13.18 Hz | 27 | 1000 | Yes |
| 15:12 | XXXX04 | 3 | 6 | 21 | ***CRM** | 9,833 | F = 12.68 Hz | 27 | 5000 | Yes |

## Figure 7




*Comparative data with eddy current and Vision.*

beginning, the defect is small and graphics don't show anything significant. Obviously, the threshold of the alarms could be set up lower, but the consequent side effects are confusing.

Even though an artificial intelligence algorithm is used to detect periodical peaks in the alarm plane, it isn't easy to confirm if the cause of the defect is a groove roller crack or other signal like vibration type.

Once several peaks go over the alarm threshold, the operator can suspect that a GC is present. However, the experience of previous occurrences is necessary to get a confirmation.

Looking at Fig. 6, there is some important information that can be summarized.

A PDRM shows an evolution over time. The signal amplitude in terms of points gives an accurate vision about the severity of the defect during the rolling mill operation.

The graphics (Fig. 7) also show a frequency between amplitude peaks. This can be used to identify the GC periodicity in combination with production parameters such as finishing roller diameters.

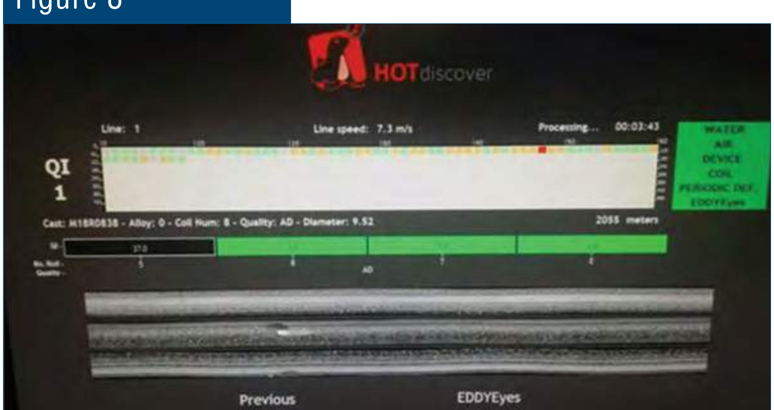
The users can set up the alarms to decide in which moment a signal can be considered as a real alarm. With the Vision module contribution, the alarms can be set up at lower levels than the standard one from eddy current because the confirmation will be done specifically by the pictures produced.

**PDRM Investigations With Vision** — The main difference by using the pictures is that once a suspect frequency in peaks is shown, the operators can look at the picture given by the Vision module. To do that, it's only necessary that frequency and peaks don't remain as the most important information from EC.

The system will produce a red alarm of a potential PDRM, including the frequency of the peaks, and then it will take pictures of the areas of the material where these peaks are produced (Fig. 8).

Then, the operator can see the alarm log, where the system will show the frequency and the related roller as well as the picture. Peaks are less important than the frequency, because the picture adds the complementary information about the defect geometry.

## Figure 8




*Map and Vision pictures as shown in the operator screen.*

**This Is the New Technological Approach** — To comply with this requirement, the basic technology must allow the real-time synchronization of the electromagnetic alarms and the image. The synchronization of both is a key element and will produce real-time images of potentially defective areas. To achieve results applicable to obtaining high-speed products such as 5.5-mm wire, the Vision equipment (Fig. 9) must be fast enough in terms of sampling frequency, typically on the order of hundreds of thousands of images per second.

But it is not the only element of development; also the lighting system must be specially designed to achieve a reflection of light according to the intended use. Poor lighting equipment could create false alarm detection.

To get the best results, the system tracks the following steps:

1. The eddy current tester measures amplitudes and phases of the eddy current in the surface of the material.
2. A development of artificial intelligence based on powerful algorithms can detect peaks of amplitude even below EC alarms and the noise level suspected of being produced by the groove roller crack.
3. Once the guilty frequency has been determined, the system will light an alarm of potential defect due to a roll break and will take images with that frequency and present them on the operator's screen.
4. The operator will analyze the images and make the corresponding decision.
5. In parallel, the artificial Vision machine takes images of all the material.
6. A development of artificial intelligence based on mathematical algorithms will detect periodic image patterns that may be associated to the equipment signals of eddy currents or not. If not, the system will light a potential defect alarm due to the presence of images available to the operator.
7. The system will discard those images that are not associated with either a defect alarm or a suspicious frequency.

In summary, the system will allow the detection of periodic defects whether they are detectable by eddy currents or if they present a similar image pattern and will be optimized so that only images of potentially defective areas are stored, discarding the rest.

EDDYeyes combines a series of elements that have already been tested and optimized in several rolling mills:

1. Digital technology of EC developed by ISEND.
2. High-speed image capture system with a resolution higher than 0.5 mm for 5.5-mm wire manufactured at 110 m/second.
3. LED lighting system developed by ISEND to improve the quality of the images.
4. Software for the analysis of periodic signals in the amplitude of the EC.
5. Software investigations for periodic image patterns.
6. Synchronization system.

Figure 9

*On-line one-strand EDDYeyes industrial unit.*

## Conclusions

The integration of EC technology and Vision emphasizes the capabilities for investigations confirming the occurrences of PDRM in hot rolling mill production. That integration generates a big data model for a new on-time surface defect management strategy replacing the 50% GC late detection efficiency with only the EC.

In addition, it opens the door to new research based on the combination of reliability given by EC and intuitiveness given by Vision, therefore allowing a new methodology for roller use and roller stock management policy.

Duplications of information (EC + Vision) along the product line are easy to install, allowing all the teams from shift operators, production management and control to understand on-time the RM surface quality with any kind of new functionalities (e.g., smartphones).

In this report, it has been explained how the new defect detection system based on the integration between eddy currents and artificial Vision developed by ISEND and called EDDYeyes contributes to the best detection of PDRM through:

1. Immediate and visual confirmation of periodic signals detected by eddy currents.
2. Immediate identification of broken rolls.
3. Expansion of the traditional capabilities of the eddy current testers to the treatment of periodic images to increase the typology of detectable defects.
4. User-friendly solution.

## References


1. B. Chedal Anglay, "Process/Quality Opportunity Improvements Through Integrated CC/Wire Rod Tracking Coupled With Hot Eddy Current Wire Rod Data," *AISTech 2014 Conference Proceedings,* 2014.
2. B. Chedal Anglay, "Hot Surface Defects Detection Synchronizing Eddy Current + Vision: A New Reliable Technology for Consistent Continuous Improvements on Time in the Long Product Metal Industry," *AISTech 2018 Conference Proceedings,* 2018.
3. J. Ignacio Lucas, "Surface-Critical Defects Analysis in Hot-Rolled Long Products, Wire Rod and Bars With Eddy Current and Artificial Vision Testing," *AISTech 2018 Conference Proceedings,* 2018.
4. E. Gómez de León, "Induced Currents Level II," *Fundación Confemetal*, Madrid, Spain, 2009.
5. J. García Martín, "Contributions in the Area of Probes and Algorithms Applied to the Detection of Discontinuities, Distance Metrology and Classification of Materials With Non-Destructive Techniques Based on Induced Currents," (in Spanish) thesis, Universidad de Valladolid, Valladolid, España, 2016.
6. J. García-Martín, J. Gómez-Gil and E. Vázquez-Sánchez, "Non-Destructive Techniques Based on Eddy Current Testing," *Sensors,* Vol. 11, 2011, pp. 2525–2565.
7. S. Saludes-Rodil, E. Baeyens and C. Rodríguez, "Unsupervised Classification of Surface Defects in Wire Rod Production Obtained by Eddy Current Sensors," *Multidisciplinary Digital Publishing Institute, Sensors 2015,* Vol. 15, No. 5, pp. 10100–10117. ✦


AISTech

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# Controlling Equipment Failures Caused by Petroleum-Based Fluid Degradation

Author

John Schlobohm
engineering manager, American Chemical Technologies, Fowlerville, Mich., USA
dryfly@pintime.com

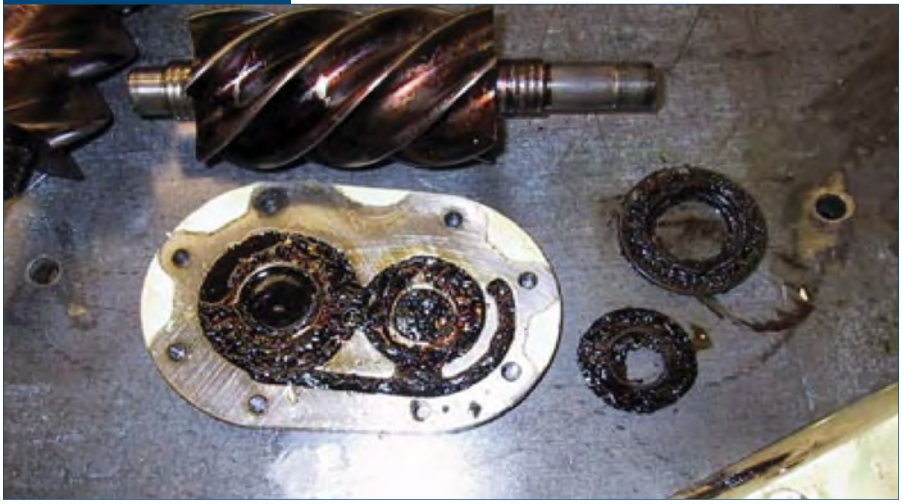
Air compressors, gearboxes and hydraulic systems that use mineral oils are susceptible to varnish and sludge. The life expectancy of petroleum-based fluid is generally determined by the rate of oxidation. When oxygen comes in contact with a petroleum-based fluid, oxidation occurs. The problem is usually dealt with by dumping the fluid and flushing the system or purchasing a varnish removal filter. New fluid technology is eliminating this problem in a way that is much less expensive and more efficient. Suppliers have developed oil-soluble polyalkylene glycols that, when added to the oil in small amounts, eliminate varnish, reintroduce oxidation additives and decrease total acid number.

Due to technology advances, the physical size of production equipment is becoming more compact. Revamped internal components allow faster operations with more precision and power in a smaller package. Auxiliary pieces like gearboxes, hydraulic components and air compressors, which have also been reduced in size, must contend with higher production demands. Equipment engineers and designers are constantly pressing to get more production out of their equipment.

One area that size reduction affects is lubricant holding capacity. Smaller capacity provides less volume into which heat can dissipate — less ability to pull out heat generated during operations. New fluid technologies have relieved some, but not all, of the problems associated with high temperatures.

Air compressors, gearboxes, oil-circulating systems and hydraulic systems that use mineral oils are susceptible to varnish and sludge (Fig. 1). This is an inherent problem associated with petroleum-based

Figure 1



*Compressor parts damaged by varnish.*

fluids. The life expectancy of petroleum-based fluid is generally determined by the rate of oxidation. When oxygen comes in contact with a petroleum-based fluid, oxidation occurs, causing sludge, varnish and an increase in total acid number (TAN). High temperatures exacerbate the development of varnish, which can cause major operational problems.

Some companies with large oil-circulating systems have purchased costly filtration devices to remove suspended varnish. This process, however, will do nothing to remove varnish that has plated out on equipment metal. Draining the system and then cleaning with solvent is another expensive solution to a varnish problem. Today, however, advancements in technology have made varnish filters and solvent cleaning unnecessary. This paper will discuss this new method.

## Polyglycol Technology

Polyglycol products have been available since the 1940s in the form of water glycol, which was developed by Dow Chemical for use in the mining industry and in Navy ship-board hydraulic systems. Today, water glycol is used in many industries where fire-resistant fluids are needed.

The glycol family is large, ranging from basic glycol antifreeze to sophisticated pharmaceutical glycols. A large portion of the family, polyalkylene glycols (PAGs), are used as synthetic lubricating fluids, providing many advantages over other fluids and oils used to lubricate equipment. PAGs are not a petroleum-based product. They are made from natural gas and therefore do not have the inherent problems of oxidation and varnish that petroleum-based mineral oils and polyalphaolefins (PAOs) have. PAGs also can handle large water incursions. Compared to mineral oil, which can handle 300 to 500 parts per million of water before degrading, PAGs can handle more than 10,000 parts per million (1%) water before steps would have to be taken to curb the infiltration. When water does occur in quantity, fluid degradation does not occur. Any free water can be removed with a vacuum dehydrator with no damage to the PAG. Many papers have been written about polyalkylene glycols. While some have been very accurate as to the advantages and disadvantages, some have not. This paper focuses on the ability of a polyalkylene glycol molecule to not varnish, how the molecule attracts free radicals (oxygen atoms) in mineral oil, and how adding PAG technology to petroleum-based fluids will control varnish and give longer life to the fluid.

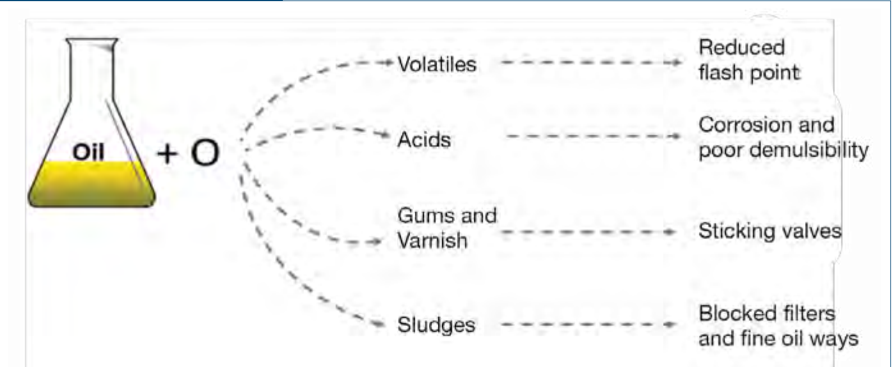
There are three basic types of polyalkylene glycol: insoluble in water, water soluble and oil soluble. Each was developed to provide specific lubricating characteristics and each has a place in industry with distinct advantages.

## Oxidation and Varnish

An oil-soluble polyalkylene glycol (OSPAG) has recently been developed that, when added to petroleum-based oils, reverses oxidation and rehabilitates the fluid back to a usable and stable condition. Varnish is a product of petroleum-based oil oxidation. Oxidation is caused when a free radical (oxygen atom) infiltrates an oil molecule (Fig. 2). Oxygen is a very reactive atom and can cause an increase in the molecule's total acid number. The acid that is developed will eventually cause total degradation of the oil. Heat, water and contaminants can accelerate this action. To help alleviate this action, oil suppliers blend oxidation inhibitors (usually amines and phenols) into finished mineral oil. The inhibitors are polar and attract free radicals (oxygen atoms) away from the lubricating oil molecule, thereby reducing the chances of oxidation.

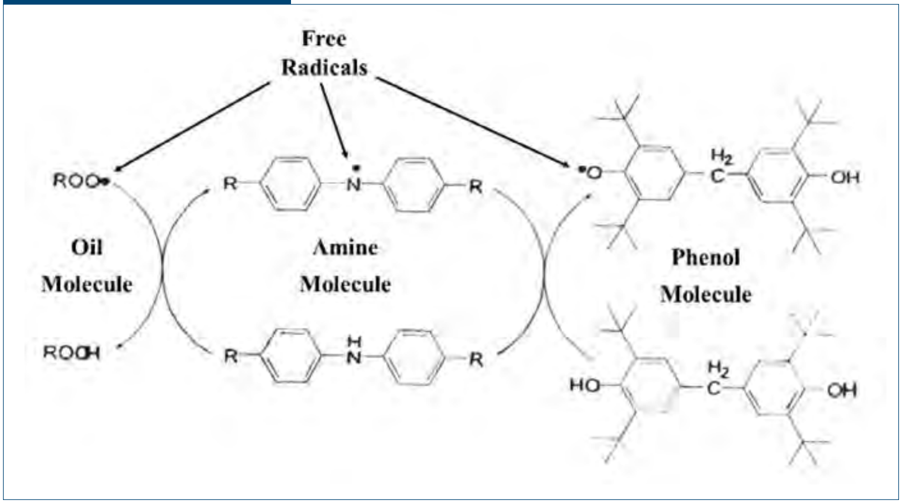
Generally, the amine molecule is the active element in the antioxidant additive package. It receives the free radical and then passes it off to the phenol molecule (Fig. 3). This action continues until both the amine and phenol molecules become totally saturated with free radicals (Fig. 4). At this point they drop out of solution and become a varnish particle. The particle not only traps amines and phenols, but it will also pull in free water molecules and even very small contaminant particles. Because they are extremely polar and loaded with free radicals, the varnish molecules

Figure 2




*Heat, water, air and contamination will accelerate the oxidation.*

Figure 3




*Simplified version of antioxidants in action.*

will be attracted to each other, producing larger particles, or will be attracted to, and plate out on, metal surfaces such as bearings, valves and rotating devices.

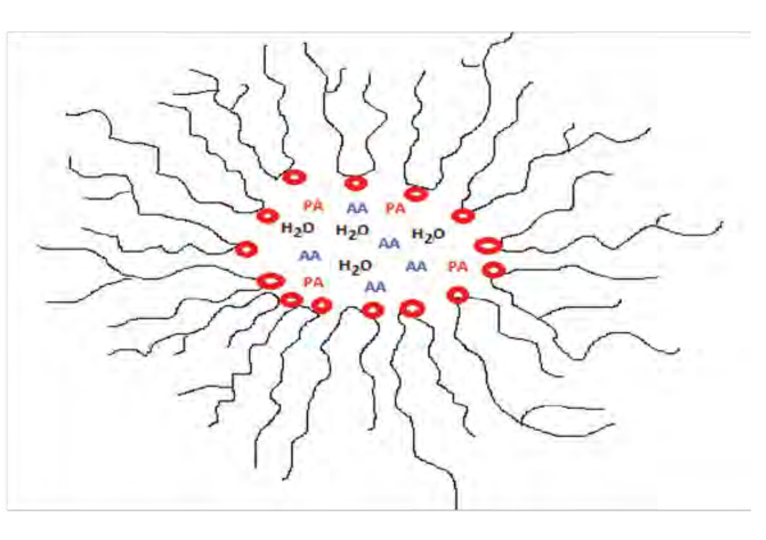
Places where temperature gradients are found, such as between rolling elements in a bearing or in small oracles in hydraulic valves, are natural places where the varnish molecule will plate out. Plating in turn increases heat generation, causes hydraulic valves to stick and reduces overall system efficiencies.

The increasing acid numbers will cause the oil to degrade rapidly to the point where it is no longer usable. Until now, dumping the system and recharging has been the only solution. With new fluid technologies, however, this expensive solution can be avoided. Adding a small portion of oil-soluble polyalkylene glycol into systems using mineral oil will solve these varnish problems.

The OSPAG is not an additive that adds antioxidation amines and phenols to the oil solution, it is a base oil modifier. It actually attacks varnish, leaving the original antioxidants to resume their protection (Fig. 5). When added to the base fluid, OSPAG shifts the polarity and gives the modified base oil the ability to resolubilize varnish throughout the system. This is accomplished when 10–15% OSPAG fluid is added to the mineral oil system. Because PAG oil is soluble, it mixes completely without compatibility issues. The polyalkylene glycol molecules are extremely polar and will remove the free radicals that have attached themselves to the amines and phenols that have fallen out of solution. By removing the free radicals, the antioxidants are now free to go back into solution. One-third of all atoms in a PAG molecule are oxygen atoms, so they readily accept the free radicals without causing other problems. The radical cleansing not only removes the varnish radicals from suspended particles, but will also pull oxygen atoms from varnish that has become attached to metal surfaces allowing those antioxidants to become soluble again.

Not only will the OSPAG remove the free radicals from the varnish molecules, but it will also pull oxygen atoms that are in fluid solution, thereby stopping the radicals from getting to the mineral oil molecule. As the radicals are released from the varnish molecule, small trapped water molecules are also released. These are generally not an issue because the small amounts are soon dissipated through vaporization.

Figure 4

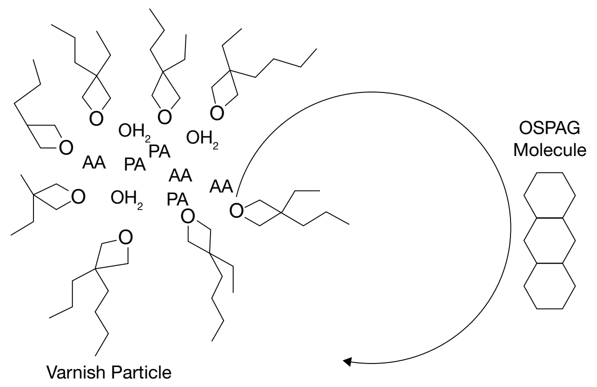



*Anatomy of a saturated varnish molecule.*

## Concerns

Not every application is suitable for the use of OSPAGs. For instance, do not use PAGs in reservoirs that have been painted, unless it's epoxy paint. Glycol-based products are a great paint remover and

Figure 5




*Oil-soluble polyalkylene glycol molecule breaking up a varnish particle.*

undissolved paint can clog filters or contaminate system components.

Another place OSPAGs should not be used is with petroleum-based oils that have zinc additives. Zinc is not compatible with any polyalkylene glycol and will cause gumming.

And finally, older systems that use organic seals, O-rings or gaskets should not use any synthetic fluid. Synthetic fluids can cause these products to shrink or swell, depending on the fluid, and leak.

It is suggested that before using OSPAG in any application, consult with the supplier on its use in the application.

## Results

The usual time period for the OSPAG to work effectively is dependent on the condition of the system when it is converted. The typical period is about 45–60 days; however, the long-term working effect, in most cases, can be several years. The oil should be sampled on a routine basis to determine its condition. The TAN will be the determining factor as to the life of the fluid. As the varnish molecule is broken, releasing the antioxidants back into solution, the TAN will lower.

As seen in Fig. 6, OSPAGs have removed the varnish from filters used in a hydraulic system. These results were accomplished in 45 days using a 10% addition of OSPAG.

Figure 6


*Varnish has been removed from filters in a hydraulic system.*

## Conclusion

Because companies are demanding greater production from their equipment, lubrication fluid maintenance has become critical. Technologies have been developed to handle greater fluid stress and longevity, however the basic problem that petroleum fluids have — varnish — is still a problem.

Oil-soluble polyalkylene glycol is a base oil modifier that, when added to mineral oil or polyalphaolefin, reverses oxidation and acid accumulation, both detrimental to equipment.

Depending on the condition of the base oil, the amount of OSPAG needed to reverse the degradation can be from 8% to 15%, and the time for it to completely transform varnish can range from as little as two weeks up to three months. ✦

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# Reduction of Maintenance Costs and Improved MTBR of Boiler Steam Drum and Superheat Safety Valves

Authors

Tim Shelton
ArcelorMittal, Burns Harbor, Ind., USA
timothy.shelton@arcelormittal.com

Charles Kuntz
ArcelorMittal, Burns Harbor, Ind., USA
charles.kuntz@arcelormittal.com

Larry Frey
ArcelorMittal, Burns Harbor, Ind., USA
larry.frey@arcelormittal.com

The goal of this project was to reduce the cost of maintenance and repair of the safety valves on all six boilers at ArcelorMittal Burns Harbor. Historically, the practice has been to disassemble and replace the parts for every valve annually. Studies show that the majority of valves that are disassembled do not require a total disassembly and repair. The U.S. Occupational Safety and Health Administration states that each company will establish a good engineering practice on the frequency and type of repair based on the historical data collected. By changing the frequency and type of testing, the time between repair has been increased from one year to two years.

The boilers at ArcelorMittal Burns Harbor's power station have high-pressure drum and superheat valves that are welded in-line. This eliminates any flange issues that could arise and leaves the valves suitable for field repairs. The valves are all 1700 series Maxi-flow safety valves. They range in setpoint from 1,025 to 1,050 psi on the drums and 950 psi on the superheats, and meet the American Society of Mechanical Engineers (ASME) code requirements for setpoint and capacity for the plant boilers. Lake Michigan water is processed by a reverse osmosis system to remove impurities prior to reaching the boilers.

Since the requirements on manpower, training and certifications do not make it cost-effective to repair the valves in-house, the plant has maintained a process of using a vendor to repair the safety valves. Historically, a complete disassembly, replacement of the disc, resurfacing the nozzle and resetting of the valves was included in the annual rebuild of each valve. The in-line setting of the valves was done with a hydraulic lift assist device as the boiler was being returned to service.

## Discussion

**Past Practice —** Prior standard practice was to repair valves during annual outages. Vendors would disassemble, repair and reset the valves on each boiler. This work was usually completed in two to three days with an additional day for testing the valves after the boilers were being brought to operating pressure. This was considered the best practice based on the time allowed for boiler outages and the many critical jobs being performed concurrently. The need for certified repair facilities to conduct the repairs allowed for the vendors to develop the practice of automatically replacing the discs in the valves at each downturn.

**Costs —** The cost of a certified vendor, scaffolding services, replacement discs and time to test valves at start-up are incurred at each boiler outage.

**Justification for Improvement —** Per the ASME code, the maintenance of pressure-relieving devices falls on the owners of the valves. The owners are required to follow guidelines set by the National Board of Boilers and Pressure Vessel Inspectors and those in the National Board Inspection Code (NBIC) book.

Based on this information, it is not required to disassemble the valves and perform repairs on each valve every year. Per the U.S. Occupational Safety and Health Administration (OSHA) standard,



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## Figure 1

| Asst Number | Location | Manufacturer | Model Number | Size | Set Pressure | Capacity | Serial Number | Notes | Last Repair/Test | Testing Frequency | ASME Code | Next Repair | Vendor |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| M6015261202 | #7 North Drum | Consolidated | 1747WA-2-S | 3 | 1025 | | BS02364 | disc/VR | 7/3/2018 | 2 | v | 7/2/2020 | Emerson |
| M6015261204 | #7 South Drum | Consolidated | 1747WA-2-S | 3 | 1050 | | BS02365 | disc/VR | 7/3/2018 | 2 | v | 7/2/2020 | Emerson |
| M6015261206 | #7 Superheat | Consolidated | 1747WD-2-S | 3 | 950 | | BS02366 | disc/VR | 7/3/2018 | 2 | v | 7/2/2020 | Emerson |
| M6015281202 | #8 North Drum | Consolidated | 1747WA-1-S | 3 | 1050 | | BM9328 | Tested | 5/31/2017 | 2 | v | 5/31/2019 | MVS |
| M6015281204 | #8 South Drum | Consolidated | 1747WA-1-S | 3 | 1025 | | BM9327 | Tested | 5/31/2017 | 2 | v | 5/31/2019 | MVS |
| M6015281206 | #8 Superheat | Consolidated | 1747WD-1-S | 3 | 950 | | BM9329 | Tested | 5/31/2017 | 2 | | 5/31/2019 | MVS |
| M6015301202 | #9 North Drum | Consolidated | 1747WA-1-S | 3 | 1025 | | BM9330 | disc/VR | 5/4/2018 | 2 | v | 5/3/2020 | Pentair |
| M6015301204 | #9 South Drum | Consolidated | 1747WA-1-S | 3 | 1050 | | BM9331 | disc/VR | 5/4/2018 | 2 | v | 5/3/2020 | Pentair |
| M6015301206 | #9 Superheat | Consolidated | 1747WD-1-S | 3 | 950 | | BM9332 | disc/VR | 5/4/2018 | 2 | v | 5/3/2020 | Pentair |
| M6015321202 | #10 North Drum | Consolidated | 1747WA-1-S | 3 | 1050 | 191750 | BL8610 | test only | 1/18/2018 | 2 | | 1/18/2020 | |
| M6015321204 | #10 South Drum | Consolidated | 1747WA-1-S | 3 | 1025 | 192150 | BL8609 | test only | 1/18/2018 | 2 | | 1/18/2020 | |

*Example of the drum and superheat valve list.*

the frequency of complete repairs should be based on "good engineering practices." The historical data was reviewed, including purchase orders written for repairs on the drum and superheat valves with power station personnel. It was determined that the practice of completely repairing valves every two years instead of every year would be acceptable. The practice of examining the seats for any defects and measuring the "critical dimensions" (height of seats on the thermal discs) and reusing them if they were within the standards for the size of the valve was also initiated.

Testing the setpoint in the non-repair year is done to ensure the functionality of the valve is maintained. This is based on several conditions, including: (a) no visible signs of leakage, (b) proper reseating without leakage if it had lifted and (c) meeting the setpoint criteria when tested in-line under normal operating conditions in the previous 12 months.

**Actions Taken —** The process followed was to build a database of all superheat and drum safety valves. The valves were identified by their unique serial numbers and each valve has a file that also includes the setpoint, capacity, asset number, model number, last repair/reset date, frequency of testing, applicable ASME code and vendor who performed the work (Fig. 1). Each valve has its own tab where the valve repair documents can be attached and is readily available. This is posted on a company SharePoint site enabling the information to be accessible to all power station personnel and is updated after every boiler outage.

The process enables the power station staff to determine, as each boiler outage was planned, whether they needed to repair or simply test the valves. It has also been established that the valves could be tested in-line prior to bringing the boilers down in a non-repair year to determine if they meet the setpoint criteria. If they meet the criteria, no additional work is required until the following year. Pre-outage testing eliminates having to test the valves at the end of an outage.

A lunch-and-learn on pressure relief valves was developed to educate power station staff on safety/relief nomenclature and what was included in the new process. It was also stated that vendors would be required to have a "VR" stamp certifying that they adhered to the ASME code requirements for the correct repairs to pressure-relief devices. A procedure stating the policy on how these valves would be maintained was developed and is updated as necessary, including the information on vendors and frequency of testing. Safety valve repairs are incorporated in the process developed at the power station for planning outages. The process for safety valves began in Q4 2017 and was utilized in 2018, with a cost savings of 61%.

Another benefit of utilizing this new program has been retaining used, but acceptable, discs that previously would have been discarded. At the time of this writing, four of these discs had been used. Since vendors are not required to automatically replace the discs, there has been no need to purchase discs.

## Conclusions

The Burns Harbor power station staff was able to make informed, economical decisions on the maintenance path to use on the drum and superheat safety relief valves: extending the mean time between repairs to two years for each boiler safety valve, leading to reduced labor and material costs.

## References


1. PD665 – ASME BPV Code, Section I: Power Boilers.
2. National Board Instruction Codes (NBIC).
3. T. Shelton, Power Station Cost Savings. ✦


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# Maintenance Practices of Gas Analyzers in Steel Industry

Authors

Ashish Garg (pictured)
senior manager instrumentation,
Tata Steel India,
Jamshedpur, JH, India
ashish.garg@tatasteel.com

Pradyot Basu
Tata Steel India,
Jamshedpur, JH, India
pradyot.basu@tatasteel.com

In the iron and steel industry, the use of process analytics is required at several locations of the plant with different objectives. The measured data obtained from the analyzers are used to monitor and control the function and economic efficiency of the process, safety for personnel and equipment, and environment protection. Tata Steel has adopted many good practices to make gas analyzer measurement reliable. Until now, the number of interruptions has been reduced to two digits for every 40 gas analyzer measurements. Tata Steel worked to reach single-digit interruption for 40 gas analyzer measurements by the end of 2019.

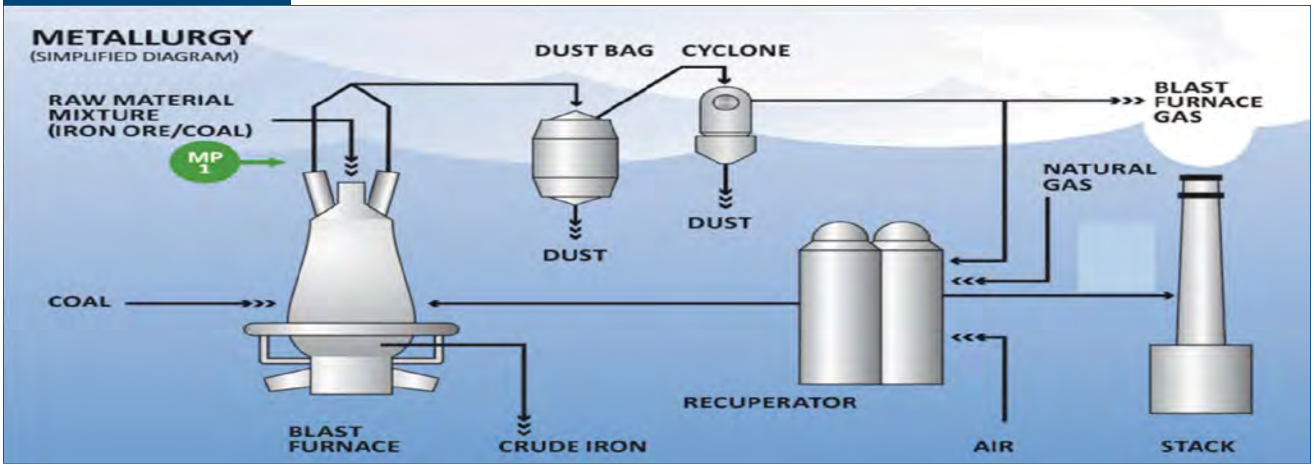
Challenges in the maintenance and reliability of gas analyzer systems in the steel industry have drawn serious attention for maintenance engineers all over the world due to the continuous evolution, innovation and complexity of modern technologies. These systems need very high reliability and availability due to the critical business, environment and safety nature of iron and steel operations. This paper reviews equipment maintenance strategies practiced over the years in complex integrated steel production systems. The paper also examines the current maintenance and reliability philosophies, their limitations, and highlights major breakthroughs and achievements with regard to complex engineering systems maintenance. Intelligent maintenance, a novel approach to complex engineering systems maintenance and reliability sustainment, is proposed. The approach reintegrates the maintenance phase into system development by adapting advanced engineering methodologies to develop condition-based predictive maintenance, an intelligent maintenance system with resilient, autonomous and adaptive capabilities.

## Importance of Gas Analyzer in Blast Furnaces

**Blast Furnace Top Gas Analysis —** Gas analyzers are widely used in process control applications. They are used in monitoring the process parameters and in safety interlocks if any of the process parameters go above or below the desired operating limit.

The blast furnace (BF) is a type of metallurgical furnace (shown in Fig. 1) used for smelting to produce industrial metals, generally iron, but also others such as lead or copper. The operation status of the BF is closely connected with the ironmaking process, coke consumption, molten iron quality, etc. Top gas is not only a secondary fuel for coking, power plant, heat treatment, and other usages in the iron and steel production process, but is also a critical reference for scheduling workers to forecast the operation status of the BF. The BF is a highly complex system and thus it is very difficult to assess the internal state of the process by direct measuring, including the spatial and temporal distribution of temperatures and pressure. The operation status must be assessed based on the incoming and outgoing flows, as well as the conditions at the furnace boundaries. Top gas data can be easily obtained relative to the internal data of BF and is a critical indicator to reflect the operation status of BF. Therefore, it is necessary to study

Figure 1



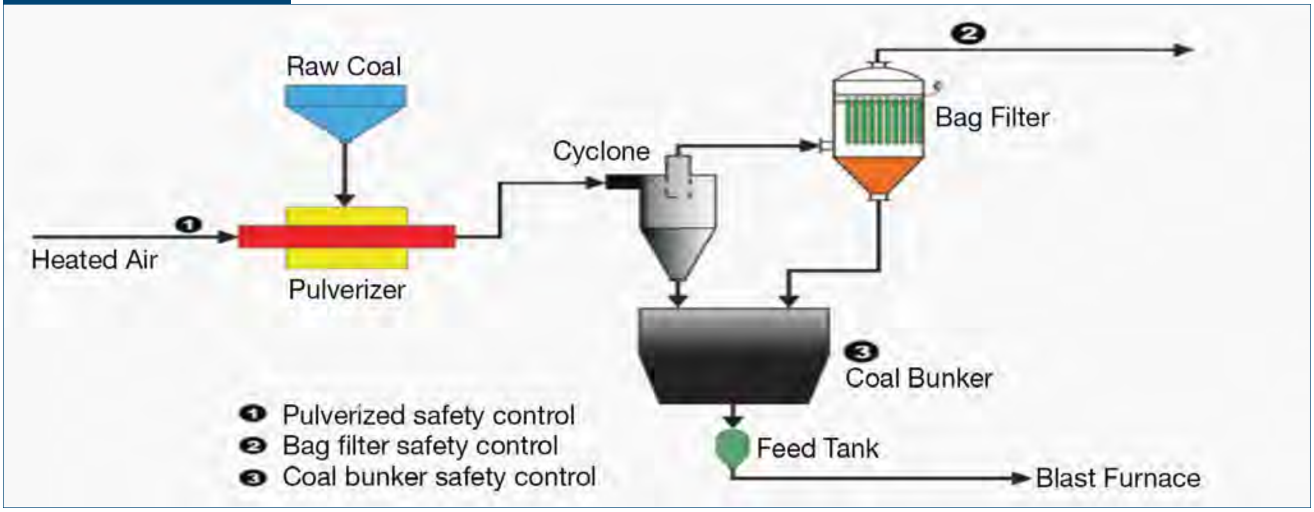

*Blast furnace process.*

a real-time automatic prediction method for top gas indices. The operation status of the BF is reflected by indices such as the contents of CO, $CO_2$ and $H_2$ (MP1 in Fig. 1). The percentage of CO and $CO_2$ in BF gas is directly related to the amount of carbon in the charged coke and amount of $CO_2$ in the charged flux (limestone and dolomite). The coke rate (the rate of carbon consumption) in the blast furnace depends upon mainly the type of the hot metal to be made, the chemical and the physical characteristics of the charged materials, the distribution of the materials in the furnace stack, the temperature, and the oxygen enrichment of the hot air blast. The total amount of CO + $CO_2$ gases by volume in the BF gas at the furnace top is around 45% of the total gas volume. The hydrogen content of the gas can vary from 2% to 5% depending upon the type and amount of fuel injected in the tuyeres of the blast furnace.

Pulverized Coal Injection Plant — The concept of coal pulverization stems from the belief that if the coal is made fine enough, it will burn almost as easily and efficiently as a gas. The raw coal is fed into the coal mill along with heated air. As the coal gets crushed, the hot air dries it and blows the usable fine coal powder out, which is then transported directly to the blast furnace or to the coal bunker for storage. The exhaust air is then purified by a bag filter. Fig. 2 shows the coal grinding and injection process.

A mix of fine coal powder and hot carrying air is inevitably creating carbon monoxide (CO). For safety operation, a continuous monitoring of oxygen ($O_2$)

Figure 2



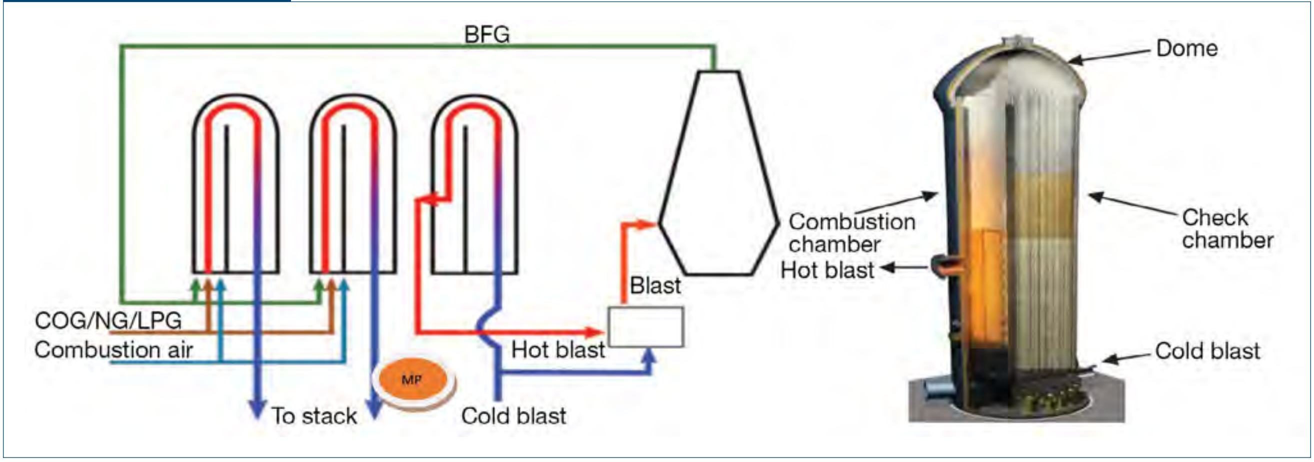

*Coal grinding and injection process.*

and trace carbon monoxide in each process of coal pulverization, transfer and storage.

Hot Stove Gas Analysis — Hot stoves are very important auxiliary equipment to the blast furnace (BF), providing hot blast to the process. The blast provides thermal energy and reducing gas to the BF process through combustion of coke and injected fuel at the tuyere level. The target for hot stoves is to provide a high and stable blast temperature. Higher blast temperature leads to lower coke and pulverized coal/natural gas consumption in the BF. The hot stove is a thermal regenerator and a simple structure of hot stove is presented in Fig. 3. An individual stove can be divided into three sections: combustion chamber, dome and checker chamber. During the period of on-gas, the blast furnace gas (BFG), often together with an enrichment gas, is combusted and the hot flue gas flows through the combustion chamber, the dome and then the checker chamber. The checker chamber is filled with refractory bricks with channels to provide a large surface area for heat transfer as well as a large volume for energy storage. The checker brick is heated and stores the thermal energy. After on-gas, the stove is switched to on-blast where the cold blast is heated by flowing from the bottom of the checker, through the dome and then to a part of the combustion chamber. When the hot blast leaves the stove, it is often mixed with a certain amount of the cold blast to produce a constant flow with a stable temperature before it is injected into the BF, as shown in Fig. 3. Real-time monitoring of carbon monoxide and oxygen in the waste gas after combustion through stack ensures stove combustion efficiency and safe operation.

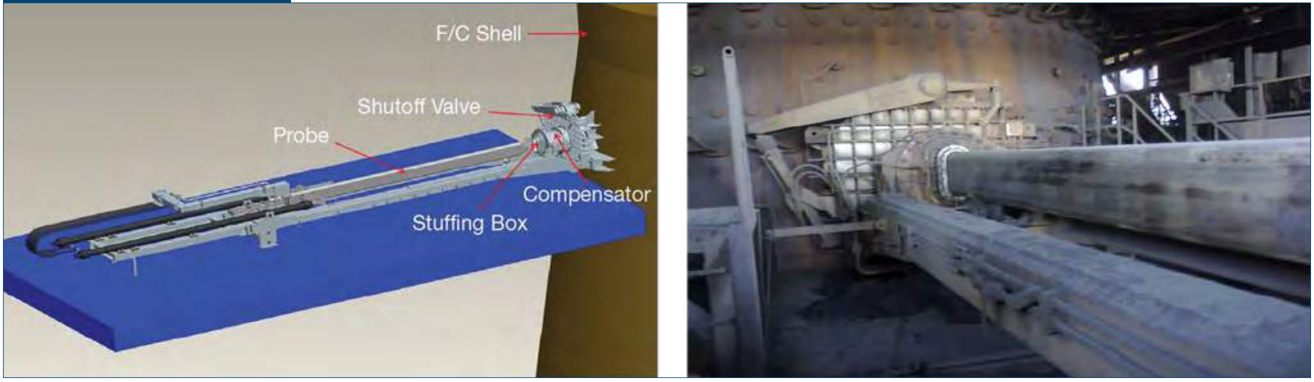
In-Burden Probe Gas Analysis — The in-burden probe (Fig. 4) enables the gas distribution and gas temperature in the blast furnace to be assessed by analyzing the overall composition of gas and its thermal profile.

Figure 3



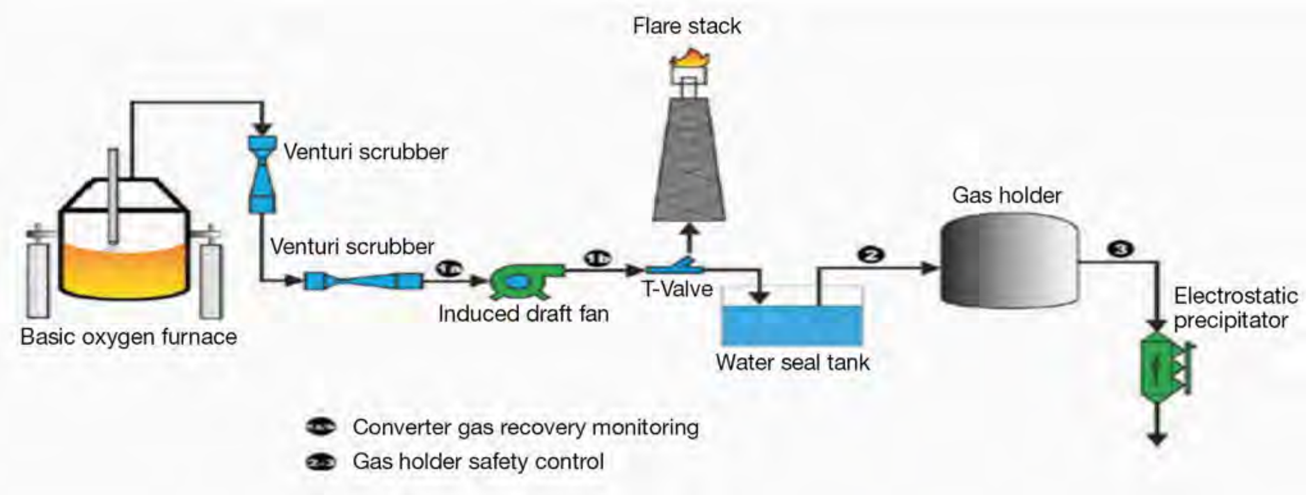

*Hot stove process.*

Figure 4




*In-burden probe.*

Figure 5




*Steel melting shop process.*

The lance is pushed horizontally at 4.5 m under the maximum stock line level of blast furnace shaft. The lance can travel to maximum 10 points on the blast furnace radius for gas sampling and gas temperature. The gas sample at each point is directly transmitted after passing through a sample-handling system to CO and $CO_2$ gas analyzer.

## Importance of Gas Analyzers in Steel Melting Shops

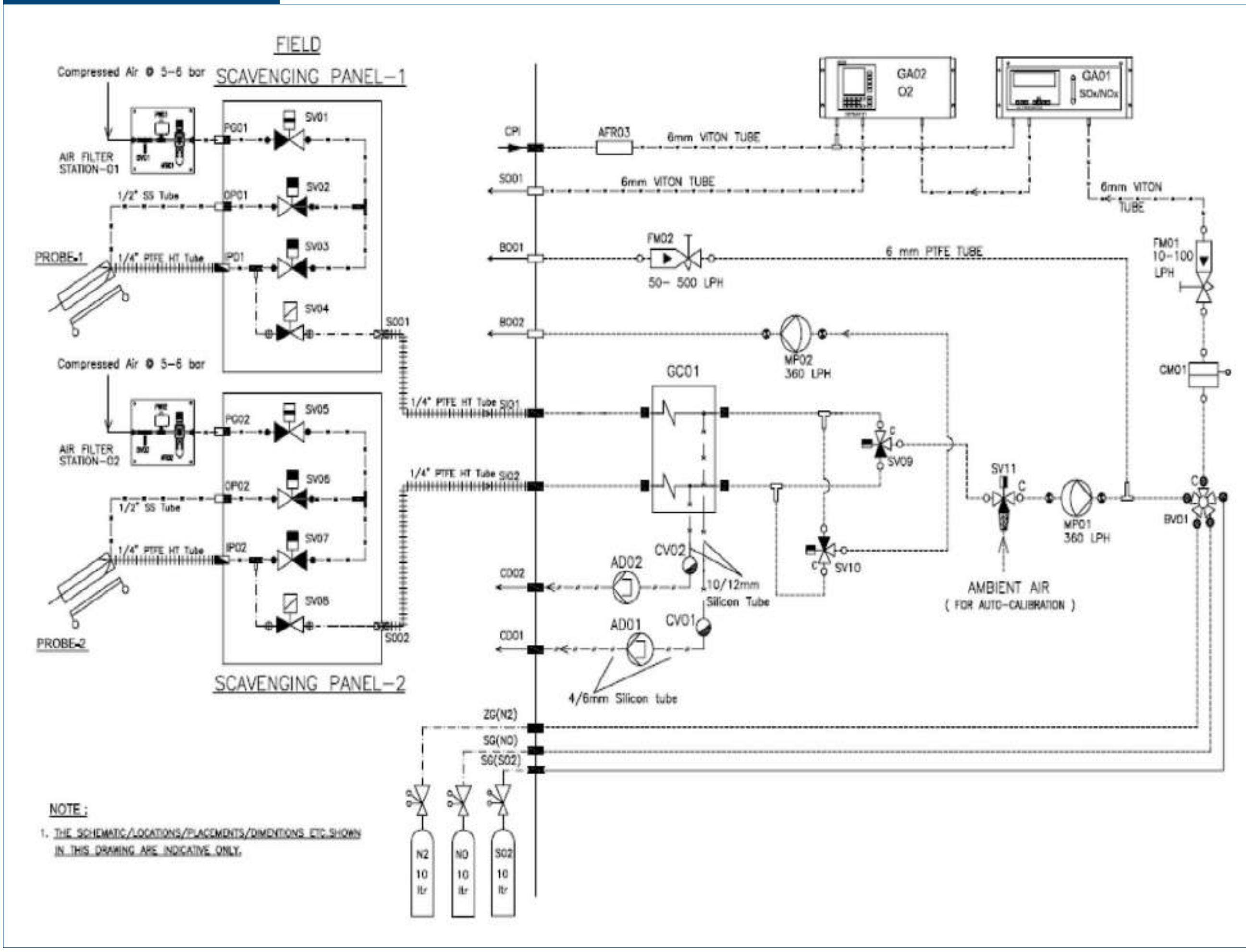
Gas analyzers at the converter shop in a steel meltshop analyze the concentration of CO, $CO_2$, $H_2$ and $O_2$ present in the converter gas at different locations; namely dry gas, wet gas and common wet gas, which is released because of blowing process. The measurement of CO concentration in a dry gas analyzer is important for the recovery, storage and distribution of gas to different customers for heating of furnaces. The measurement of $CO_2$ concentration in a dry gas analyzer is important to control the entry of air into the system and to reduce the excessive heat generated in the gas duct. The measurement of $H_2$ concentration in a dry gas analyzer is important to know the leakages of water into the converter to prevent explosion by stopping the blow. The measurement of $O_2$ concentration in a wet gas analyzer and common wet gas analyzer is important to control the entry of air into the system and to prevent the formation of an explosive mixture in the system leading to unsafe conditions like a massive explosion, if the percentage of oxygen goes beyond 2%. From the ID fan, the gas is sent either to the flare stack for flaring or to the gas holder for storing the gas based on CO concentration (CO >30% and $O_2$ <2%). The release gas is sampled before the scrubber in hot condition by the dry gas analyzer system to measure CO, $CO_2$ and $H_2$ concentrations. The gas concentration after ID fan before flare stack is measured using a wet gas analyzer to measure the concentration of oxygen percentage. The common wet gas analyzer is installed in the common gas duct to the gas recovery plant to measure the concentration of oxygen percentage to prevent air entry into the gas holder and to stop the blowing process and gas recovery in case $O_2$ concentration is above 2%. Fig. 5 suggests the steel melting shop process.

## Maintenance of Gas Analyzer Systems in the Steel Industry

Blast furnace and steelmaking is a continuous process where gas analyzers are the safety and quality control–critical equipment throughout the steel production process. Severe heat, dust, continuous production and process safety in blast furnaces, steelmaking shops, rolling mills and gas mixing stations are major challenges in the steel industry. In each environment and every process, gas analyzers must perform safely, accurately and reliably, without any interruption. Any interruption on the gas analyzer means upsetting the total process, stopping production, etc. So, the unplanned outage of a gas analyzer leads to an opportunity for the loss of the production and directly affects the performance of the shop (especially blast furnace and steelmaking shops).

The main constituent of the gas analyzer is its sample-handling system (as shown in Fig. 6). Maintenance persons give maximum time and energy to keep the sample-handling system healthy, and any malfunctioning leads to improper process control and unwanted tripping if taken in interlocks. The sample-handling system consists of probes and filters, a gas cooler to

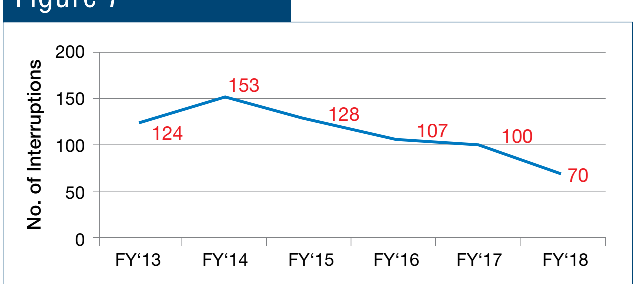
## Figure 6




*Gas analyzer sample-handling system.*

take care of the cooling of the sample gas from the process, pumps to suck the gas from the tapping point to the analyzer panel and for the condensate removal, solenoid valve (SOV) arrangement for sampling two or more points, flow switches to know the flow in the analyzer panel and the gas analyzer unit, and finally the calibration of the analyzer modules as per the process requirement.

## Figure 7




*Process interruptions due to gas analyzer.*

At Tata Steel Jamshedpur, there are more than 70 gas analyzers installed in blast furnaces and steel melting shops. Until FY'16 and FY'17, average interruptions were more than nine per month (Fig. 7). Based on the failure records of last three years and the root-cause failure analysis, major problematic areas were identified, which were responsible for 80% of downtime (shown in Fig. 8). In the last two years, substantial improvement in safety, reliability and availability of these gas analyzers has been achieved by using technology to improve maintenance practice, implementing design changes to eliminate chronic problems and adopting a system-based maintenance philosophy to sustain the improvement.

### Elimination of Sample Gas Pump Failure

Sample gas analysis systems require pumps when the process pressure is not sufficient to transport an adequate volume of sample gas to the gas analyzers. The corrosive and aggressive nature of the sample gas demands special properties of the internal component of pump that comes in contact with process media.

Since the transportation time of the sample gas is crucial, the sample pump shall be correctly sized and chosen, and shall provide the entire system with the sufficient flow and pressure from the sample point down to the analyzer.

At the I Blast Furnace, sample gas pump KNF failed due to following problems:

- Bearing seize.
- Diaphragm damage.
- Overheating.

On analysis, it was found that the sample-handling system has internal tubing of 6 mm. Due to the small-sized tube, the pump discharge pressure was more than 0.5 bar, which was higher than the rated capacity. The pump could not sustain such high pressure and it was transferred on diaphragm, bearing, shaft, etc., resulting in pump failure. The matter was discussed with the original equipment manufacturer and the following solutions were developed:

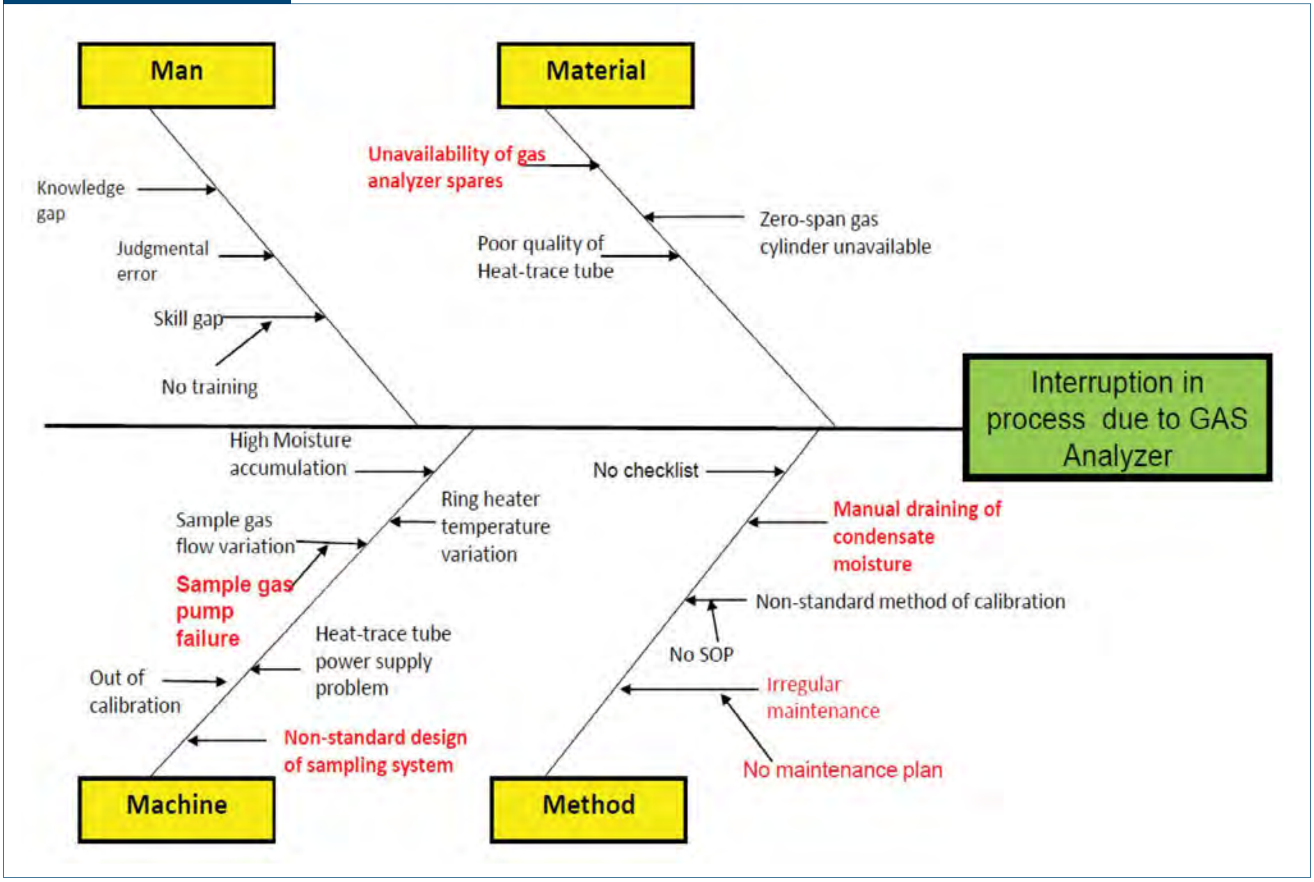
- The pump should be replaced with a new pump with more capability of handling higher discharge/backpressure.
- The 6-mm tubes and SOVs of the sample-handling system should be replaced by large diameter tubes so that the discharge/backpressure be reduced.

Based on the solution provided by the original equipment manufacturer and detail study done by Tata Steel, it was concluded to change the pump in a phase-wise manner.

Fig. 9 shows the flow vs. discharge pressure curves of the damaged pump (2040 LPH) and new suggested pump (900 LPH). The maximum backpressure sustained by 2040 LPH pump is 0.5 bar while 900 LPH pump can sustain maximum backpressure of 4 bar.

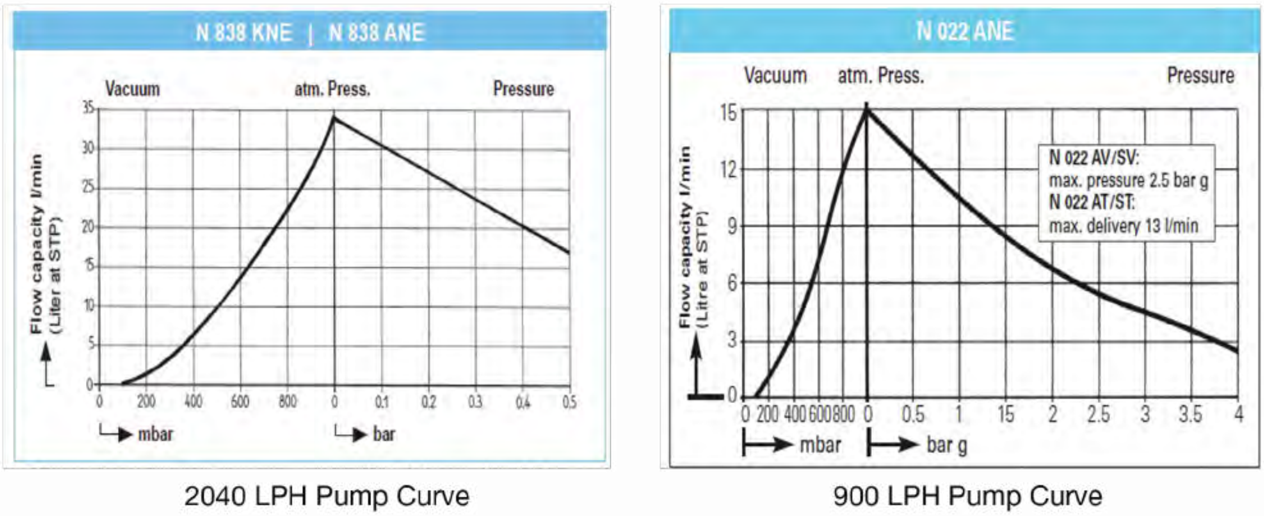
With new pump installation (Fig. 10), the problem of sample gas pump failure was eliminated. Transportation time for the gas sample to reach the gas analyzer changed from 11 seconds to 24 seconds (considering 80 m sample path length), which was allowable for process application with respect to process safety.

Figure 8




*Ishikawa diagram for gas analyzer interruptions.*

Figure 9




*Comparative study of working characteristics of both pumps: damaged pump 2040 LPH (left) and new suggested pump 900 LPH (right).*

## Improve Design of Sample Probe for On-Line Maintenance

Sample gas probes form a critical point between the process and analysis systems. They extract sample gas from the process stream and supply it to the analysis system. The design of the probe is suitable for handling the heavy dust loads with high temperature. The major problems faced with sample probes are:

- Chokage of filter.
- Maintenance requirement of filters.

Pulverized coal injection has 11 gas analyzers ($O_2$ and CO), in which six gas analyzers are related to the fine coal silo. The fine coal silo is related to coal injection process as well as coal mill process safety interlock. Fine coal dust should be handled by timely sample probe maintenances to maintain reliability. For on-line maintenance, the system must be designed in such a way that running maintenance can be done safely. Initially, the system was not designed for on-line maintenance since there was no isolation valve, as shown in Fig. 11.

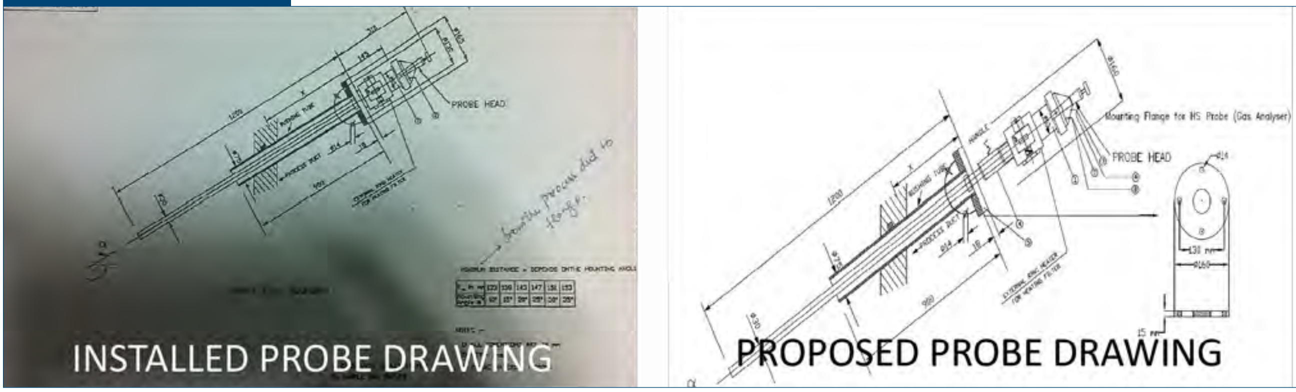
Figure 10

Problematic 2040 LPH pump, due to which coal mill and injection stoppage.

New Pump of 900 LPH installed and eliminates unwanted stoppage of coal mill and injection.

*Pump changed from 2040 LPH to 900 LPH.*

Figure 11




*Old designed probe without isolation valve vs. new designed probe with isolation valve.*

Fig. 12 shows the new modified design of the sampling probe with isolation valve; with this improvement on-line maintenance can be done safely.

## To Improve Reliability and Productivity by Automatic Condensate Drain System

In a digital world, automation plays an important role in improving the safety, reliability and productivity of the plant. Tata Steel also drives this journey throughout its plants. The sample-handling system in many areas of Tata Steel is controlled through microcontrollers or programmable logic controllers, but areas that are very old have much room for improvement. Condensate can accumulate while wet sample gas is processed through a conditioning system. The accumulated moisture is necessary to drain out to protect the measuring cells in the analyzer from damage and/or stabilize measurements. The sample gas is often conveyed through the analysis system with suction; the condensate must be pumped off to remove it. So-called peristaltic pumps are particularly suited for this purpose.

The following concerns can occur if a peristaltic pump is not present in the system:

- Manual draining needs to regularize, which decreases the productivity.
- Unsafe handling of bottles used for collection of condensate.
- Gas leakage can happen.

Figure 12


*Installation of new designed probe with isolation valve in coal injection plant.*

Figure 13


*Manual collection of condensate in bottles vs. automatic draining of condensate.*

Fig. 13 shows what the system would look like before automatic draining of condensate and after installation of a peristaltic pump.

## Reliability Improvement by Strengthening Interlocks of Sample-Handling System

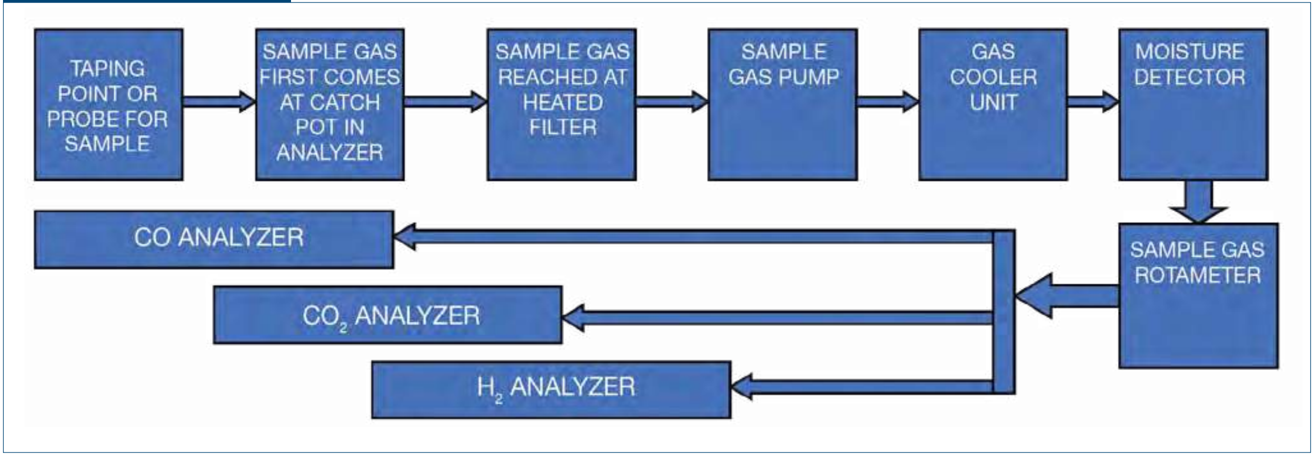
Interlocks play an important role in the sample-handling system to keep the gas analyzer safe from dust and moisture. To protect the gas analyzer from dust and moisture, a condensate monitor is used. The condensate monitor is a unit or supplementary device that is used for conditioning the sample gas. The condensate monitor is one of the most important devices used in conjunction with other devices in a sample-handling system.

The condensate monitor has mainly two functions:

- When used in conjunction with a switching unit, it serves as a device that detects the presence of moisture in the sample gas.
- The condensate monitor has a glass fiber filter paper of 2-micron particle size; this filter papers filter dust in sample gas up to 2 microns.

In FY'16, the top gas analyzer hydrogen component failed due to the ingress of moisture as the interlock of the condensate monitor did not work. On analysis, it was found that the peristaltic pump failed, thus the condensate was not removed. Due to the accumulation of condensate, it traveled to the condensate monitor and the condensate monitor malfunction allowed for the condensate to travel to the gas analyzer.

Figure 14




*Top gas analyzer schematic.*

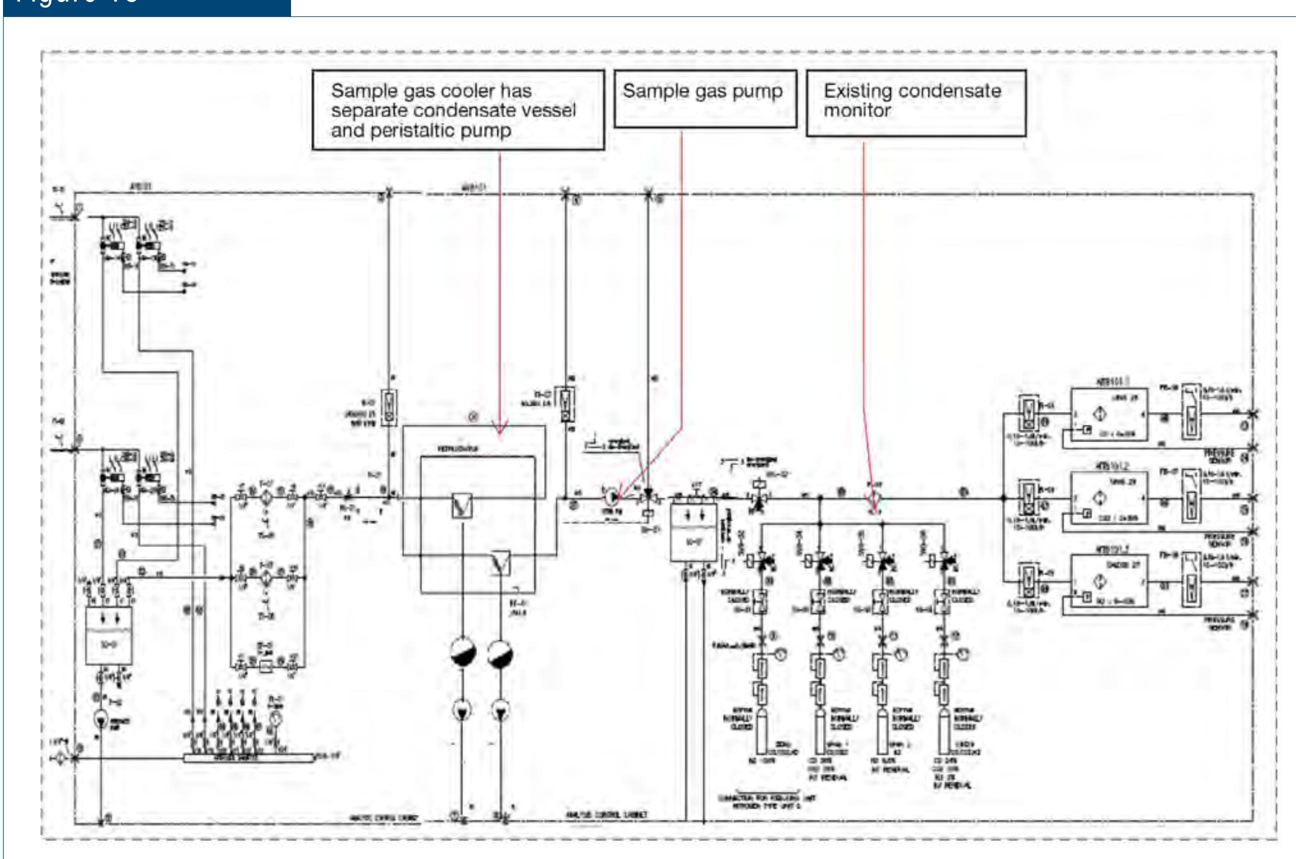
## Figure 15


*Redundancy built up of condensate monitor in top gas analyzer.*

Interlock was present, but due to the non-functioning of the condensate monitor, it did not work. Somehow, two components, the CO and $CO_2$ modules of the top gas analyzer, were protected from being damaged but the hydrogen module failed. Fig. 14 shows a schematic of the top gas analyzer.

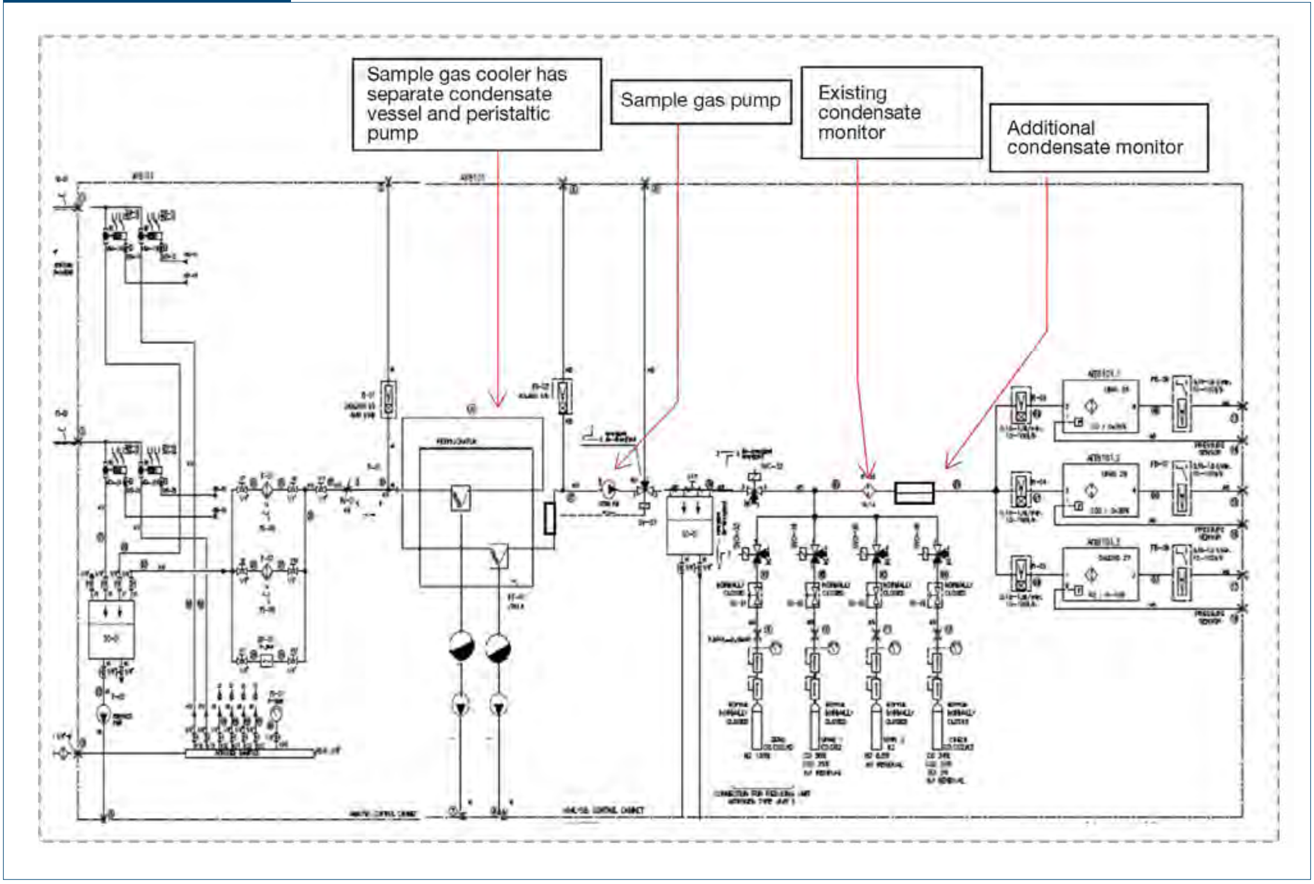
To protect the gas analyzer from such failure, redundancy had to be built up in the system in which two or three modules are installed in parallel (shown in Figs. 15–17). An additional condensate monitor was installed in series and given interlock. After implementation and horizontal deployment of the same installation in other blast furnaces, no gas analyzer has failed.

## Figure 16




*Original setup of top gas analyzer sample-handling system.*

Figure 17




*Modified setup of top gas analyzer sample-handling system.*

## Reliability Improvement of In-Burden Probe Gas Analysis Measurement

The in-burden probe is essential in the blast furnace process. It helps the blast furnace run at maximum efficiency. It provides following advantages through its measurement:

- Maximize fuel efficiency.
- Significant contribution to extending furnace life.
- Ensure uniform distribution of burden across the furnace.

Reliability of measurement is an important task for maintenance personnel, since this probe works under very harsh conditions. Maintenance of this probe is very difficult when the blast furnace is in operation since it has many critical interlocks that may affect safety.

In FY'16, measurement reliability became a concern for the maintenance personnel as gas sampling data was not correct. It became difficult for the process operators to run the blast furnace.

The gas analysis chart in Fig. 18 shows that the measuring tube of the in-burden probe became choked due to dust accumulation. The analysis suggested a pressure increase of nitrogen, which is used for purging the measuring tube after gas sampling is done.

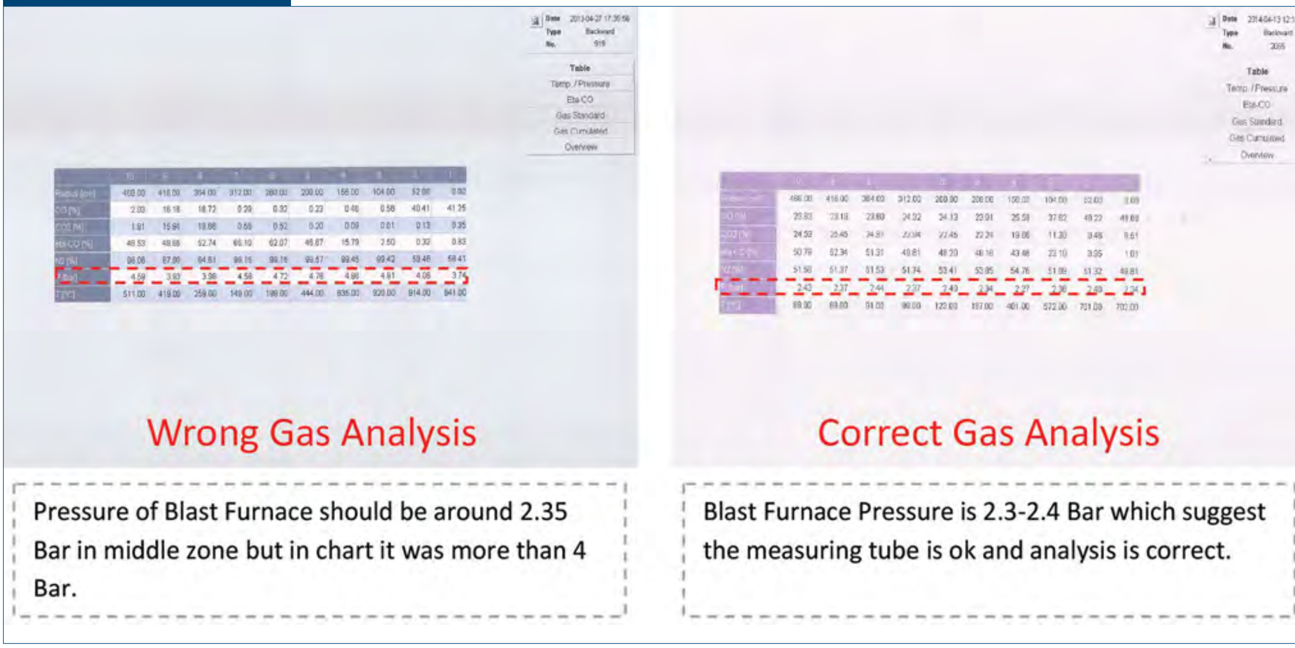
To correct the problem of dust accumulation, the design of the measuring tube was changed, as shown in Fig. 19, so that measurement becomes reliable and less maintenance is required.

After this modification, the dust accumulation problem was eliminated completely.

## System-Based Maintenance Philosophy to Sustain the Improvement

A one-time improvement can prevent recurrence and sustain the result for years to come. Every maintenance person dreams of achieving zero breakdowns between two shutdowns. To fulfill that dream, the journey for system-based maintenance started with SAP plant maintenance (SAPPM). It was decided that all the maintenance activity and calibration activity would be done through SAPPM. Necessary time-based maintenance schedule and condition monitoring points will

Figure 18




*Gas sample analysis chart through in-burden probe.*

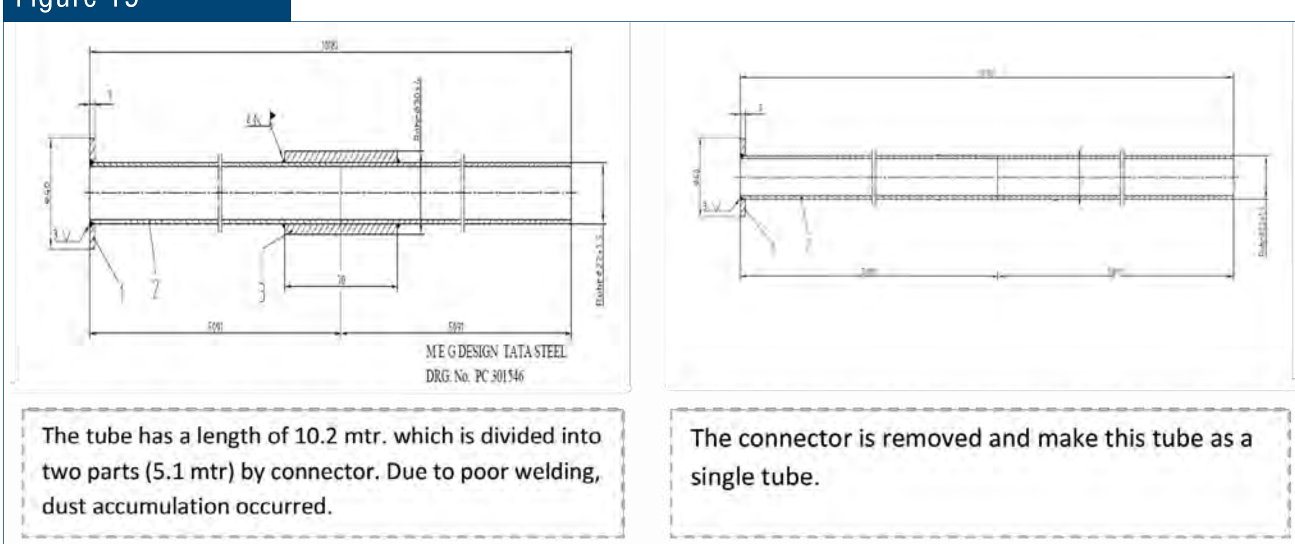
be uploaded in SAP. Shutdown maintenance is also done through checklist-based execution.

A data mining framework (Fig. 20) was also made to strengthen the process and standardize it across Tata Steel. This helps in achieving maximum reliability of measurement, strengthening process safety and lowering inventory costs.

## Results, Conclusions and Way Forward

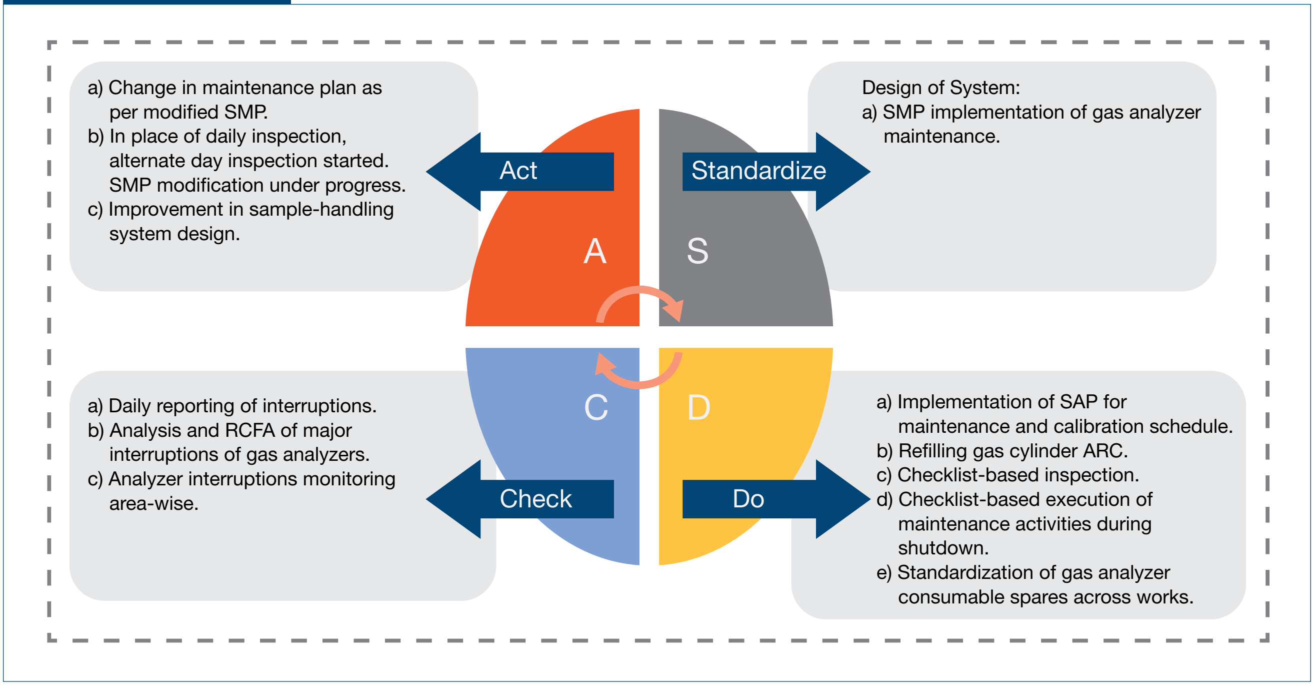
The initiative to improve reliability and availability of the gas analyzers at Tata Steel was taken in FY'17 under central maintenance instrumentation. At that time, average interruptions were around 10 per month. It initially focused on the reliability of the measurement, on-line maintenance of probes, redundancy buildup, inventory cost, standardization of

Figure 19



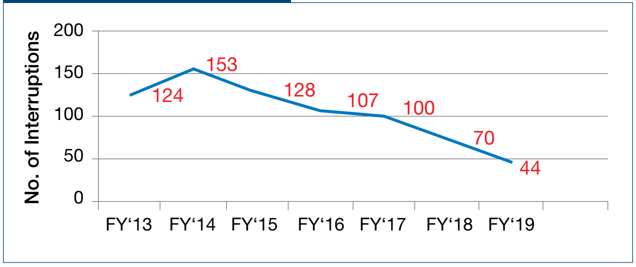

*Modified measuring tube of underburden probe.*

## Figure 20




*Data mining framework of gas analyzer at Tata Steel.*

## Figure 21




*Process interruptions due to gas analyzers.*

maintenance practices across Tata Steel Jamshedpur, and design improvement, which has given excellent results, and by FY19 Q3 the team could achieve interruptions to four per month, i.e., a 60% reduction in interruptions (Fig. 21). In FY'20, the target set for interruptions/year will be single-digit for initiatives like auto-cleaning of tapping points, and smart sample-handling systems will be under discussion.

The critical success factors of this initiative were the involvement of shop floor personnel, the focus on

## Figure 22

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| IBF | IBF_STOV | TS-IMR-IBF-IBF_STOV-INS | 10133662 | E75 | IBFESTOV | 108742 | E | IBFE-6M-INST-CAL- WGA1 O2 | STOVE WASTE GAS ANALYSI |
| IBF | IBF_STOV | | 10133662 | E75 | IBFESTOV | 108743 | E | IBFE-6M-INST-CAL- WGA1 CO | STOVE WASTE GAS ANALYSI |
| IBF | IBF_STOV | | 10133662 | E75 | IBFESTOV | 108744 | E | IBFE-6M-INST-CAL- WGA2O2 | STOVE WASTE GAS ANALYSI |
| IBF | IBF_STOV | | 10133662 | E75 | IBFESTOV | 108745 | E | IBFE-6M-INST-CAL- WGA2 CO | STOVE WASTE GAS ANALYSI |
| IBF | IBF_STOV | | 10133662 | E75 | IBFESTOV | 108746 | E | IBFE-6M-INST-CAL- WGA3 O2 | STOVE WASTE GAS ANALYSI |
| IBF | IBF_STOV | | 10133662 | E75 | IBFESTOV | 108747 | E | IBFE-6M-INST-CAL- WGA3 CO | STOVE WASTE GAS ANALYSI |
| IBF | IBF_STOV | | 10133663 | E75 | IBFESTOV | 108748 | E | IBFE 6M INST CAL CBA O2 | STOVE COLD BLAST ANALYS |
| IBF | IBF_STOV | | 10134022 | E75 | IBFESTOV | 108749 | E | IBFE-6M-INST-CAL- SC SOX NOX | STOVE CHIMNEY GAS ANALY |
| IBF | IBF_STOV | | 10134022 | E75 | IBFESTOV | 108750 | E | IBFE-6M-INST-CAL- SC O2 | STOVE CHIMNEY GAS ANALY |
| IBF | IBF_PRO1 | TS-IMR-IBF-IBF_PRO1-PROBE | 10132264 | E75 | IBFEFCE | 108763 | E | IBFE-6M-INST-CAL-IBPA | UNDER BURDEN PROBE GAS |
| IBF | IBF_PCI | TS-IMR-IBF-IBF_PCI -INS | 10132791 | E76 | IBFEPCI | 108751 | E | IBFE-6M-INST-CAL-60TPH-O2 | PCI ANALYSER |
| IBF | IBF_PCI | | 10132791 | E76 | IBFEPCI | 108752 | E | IBFE-6M-INST-CAL-60TPH-CO | PCI ANALYSER |
| IBF | IBF_PCI | | 10132791 | E76 | IBFEPCI | 108753 | E | IBFE-6M-INST-CAL-60TPH-BF-O2 | PCI ANALYSER |
| IBF | IBF_PCI | | 10132791 | E76 | IBFEPCI | 108754 | E | IBFE-6M-INST-CAL-60TPH-BF-CO | PCI ANALYSER |
| IBF | IBF_PCI | | 10132791 | E76 | IBFEPCI | 108755 | E | IBFE-6M-INST-CAL-25TPH-O2 | PCI ANALYSER |
| IBF | IBF_PCI | | 10132791 | E76 | IBFEPCI | 108756 | E | IBFE-6M-INST-CAL-25TPH-CO | PCI ANALYSER |
| IBF | IBF_PCI | | 10132791 | E76 | IBFEPCI | 108757 | E | IBFE-6M-INST-CAL-25TPH-BF-O2 | PCI ANALYSER |
| IBF | IBF_PCI | | 10132791 | E76 | IBFEPCI | 108758 | E | IBFE-6M-INST-CAL-25TPH-BF-CO | PCI ANALYSER |
| IBF | IBF_PCI | | 10132791 | E76 | IBFEPCI | 108759 | E | IBFE-6M-INST-CAL-PCSB-O2-1 | PCI ANALYSER |
| IBF | IBF_PCI | | 10132791 | E76 | IBFEPCI | 108760 | E | IBFE-6M-INST-CAL-PCSB-O2-2 | PCI ANALYSER |
| IBF | IBF_PCI | | 10132791 | E76 | IBFEPCI | 108761 | E | IBFE-6M-INST-CAL-PCSB-CO | PCI ANALYSER |
| IBF | IBF_GCP | TS-IMR-IBF-IBF_GCP -INS | 10132701 | E76 | IBFEGCP | 108762 | E | IBFE-6M-INST-CAL-TGA | GCP TOP GAS ANALYSER (C_ |

*SAP-based calibration schedule for gas analyzers.*

Table 1

*Tata Steel Standard Maintenance Practices for Gas Analyzers*

| Serial No. | Description of measuring points | Characteristic | Value-based LCL | Value-based UCL | Value-based Value | Status Y/N | Frequency |
|---|---|---|---|---|---|---|---|
| 1 | Probe heater temperature | Temperature (°C) | 100 | 150 | | | 1M |
| 2 | Heat-traced tube temperature | Temperature (°C) | 70 | 90 | | | 1M |
| 3 | Sample gas cooler temperature | Temperature (°C) | 2 | 6 | | | 1M |
| 4 | Flow of gas in Rotameter 1–Module 1 | Flow (lpm) | 50 | 80 | | | 1M |
| 5 | Flow of gas in Rotameter 2–Module 2 | Flow (lpm) | 50 | 80 | | | 1M |
| 6 | Flow of $N_2$ in Rotameter 3–Probe N2 | Flow (lpm) | 100 | 150 | | | 1M |
| 7 | Reading of the Analyzer Module 1 | ppm (%) | 0 | XXX | | | 1M |
| 8 | Reading of the Analyzer Module 2 | ppm (%) | 0 | XXX | | | 1M |
| 9 | Reading of the Analyzer Module 3 | ppm (%) | 0 | XXX | | | 1M |
| 11 | Condition of probe filter | | | | | OK/NOK | 1M |
| 12 | Current of the heat-traced tube | Current | 0 | 10 | | | 1M |
| 13 | Purging system of probes and its solenoid valves | | | | | OK/NOK | 1M |
| 14 | Tripping circuit of condensate monitor | | | | | OK/NOK | 1M |
| 15 | $N_2$/air pressure of the purging system | Pressure (bar) | 2 | 5 | | | 1M |
| 16 | Tripping circuit of Rotameter 1 | | | | | OK/NOK | 1M |
| 17 | Tripping circuit of Rotameter 2 | | | | | OK/NOK | 1M |
| 18 | Tripping circuit of Rotameter 3 | | | | | OK/NOK | 1M |
| 19 | Condition of the peristaltic pump | | | | | OK/NOK | 1M |
| 20 | Condition of the main pump | | | | | OK/NOK | 1M |
| 21 | Condition of Rotameter 1 | | | | | OK/NOK | 1M |
| 22 | Condition of Rotameter 2 | | | | | OK/NOK | 1M |
| 23 | Condition of Rotameter 3 | | | | | OK/NOK | 1M |
| 24 | Condition of bypass pump | | | | | OK/NOK | 1M |
| 25 | Analyzer purging vent lines | | | | | OK/NOK | 1M |

failure of a set of components and driving it until it is eliminated, standard maintenance practices deployment (Table 1), SAP-based inspection, maintenance and calibration (Fig. 22) through certified engineers, and ensuring the information and solutions are institutionalized/horizontally deployed across the plant. The inspection schedules along with its acceptable upper/lower limits were uploaded in the system and audited on a monthly basis for its compliance and subsequent corrective actions. The involvement of plant personnel in standardizing maintenance practices, training and knowledge-sharing, and shop floor celebrations, together with the active presence of senior management created excitement and motivation across the team, which was the major enabler for this success story.

## References


1. Adage Automation brochure.
2. Tata Steel standard maintenance practices book.
3. Focused Photonics Inc. brochure.
4. KNF brochure.


✦

# Life Extension of Motor Control Centers: When to Maintain and When to Replace



Authors

Matthew R. Hussey (left)
Eaton Corp., Fayetteville, N.C., USA
matthewrhussey@eaton.com

David B. Durocher (right)
retired, Eaton Corp.,
Wilsonville, Ore., USA
davidbdurocher@outlook.com


Facilities depend on keeping critical assets running. Often this equipment is controlled by motor control centers (MCCs) that can last for decades — even beyond their original design life. However, equipment reliability, maintenance requirements and performance rely on proper application, operation and maintenance. This paper will examine the following areas of interest when assessing motor control centers: common wear items and maintenance guidelines for MCCs; upgrading to include new technology or expanding plant capacity; weighing cost considerations to maintain versus replace; and arc flash safety considerations when maintaining equipment.

Today's global production in the steel industry continues to expand. Capacity additions are springing up in a few key strategic areas, aimed at balancing increasing demand and a fixed supply. The prospects of new capacity installations that will successfully apply state-of-the-art technologies are exciting, offering the step-change potential to improve site productivity, reliability and safety. That said, because several existing mills in industry are not operating at design capacity, the fact remains that most global demand will continue to be served from existing facilities. Many existing mills were first commissioned 40–50 years ago and some existing systems might be approaching end of life today. Mill operators of existing sites will need to focus on considerations regarding equipment replacement versus upgrades for electrical power distribution and control systems.

Electrical power in most industrial mills is the most ubiquitous asset of the production process, while also being arguably one of the most overlooked. The reason for this is simple; electrical power is presumed to be reliable and available until it is not. Most production facilities in the upper quartile for reliability and safety have rigorous and detailed preventive maintenance procedures in place to assure "the lights don't go out" unexpectedly. These include programs to complete testing during scheduled rotational outages, such as dissolved gas analysis of transformer liquids and testing of trip performance for power circuit breakers, as well as infrared scanning of electrical connections to check for hot spots and insulation breakdown.

Although a robust preventive maintenance program of electrical control and distribution systems can be effective, the plan to continue this cycle year after year without implementing either a replacement or upgrade program for these valuable assets will put yesterday's productive mill on the future road to obsolescence and eventual closure. It's an obvious fact that legacy mill electrical systems, originally manufactured 40 and 50 years ago, cannot keep pace with the rapid changes in technology. Analogously, it is certainly possible the television purchased for personal use at home back in 1975 could still be in service today, through careful and meticulous maintenance and replacement of worn or failed components. Of course, considering the extraordinary shift in technology with high-definition LED network-enabled televisions of today, it would be senseless to consider the time and cost to extend the life cycle of the 44-year-old set. In this example, replacement is the only practical option.

## Applicable Manufacturing and Test Standards

In today's modern engineered electrical systems, there are a host of assemblies that should be considered for either replacement or life cycle extension upgrades. It is important to be familiar with the major components that serve as the building blocks of power distribution and control assemblies in industry. In North American markets, the Institute of Electrical and Electronics Engineers/National Electrical Manufacturers Association (IEEE/ANSI) and Underwriters Laboratories (UL) standards prevail. Three-phase engineered electrical assemblies are the focus of this paper, specifically 600-VAC low-voltage (LV) motor control centers (MCCs) manufactured and tested to UL 845 "Standard for Motor Control Centers."[1] Typically, these assemblies include a steel supporting structure with individual compartments that contain a protective device such as an air-magnetic circuit breaker and a contactor (vacuum or air-magnetic). Each circuit breaker and contactor typically includes a protective relay to assure either cables or connected motor loads are protected in the event of an overload or system short-circuit condition. These assemblies also include main copper bus bars used as current-carrying conductors, connecting the incoming power source to the multiple devices that serve and protect individual electrical loads. Although the structure and bus components of both medium-voltage and low-voltage distribution and control assemblies are similar, considerations involving their end-of-life replacement are somewhat different. This paper will address replacement versus upgrade considerations related only to LV MCCs.

One other industry standard relevant to this review is IEEE Standard C37.20.7 "Guide for Testing Metal-Enclosed Switchgear Rated up to 38 kV for Internal Arcing Faults." Low-voltage motor control centers are optionally available as arc-tested to this standard, which was recently updated in 2017. The arc testing requirements are individually defined in multiple annex documents in the standard, each applying to a unique type of assembly. For LV MCCs, arc test procedures as outlined in Annex H of IEEE Std. C37.20.7-2017 are applicable. Other than this "add-on" arc-resistant test requiring a more robust assembly with heavier-gauge steel, bolts and latches, traditional steel enclosures for LV MCCs manufactured today are very similar to designs from 40 years ago. The main bus bar for these assemblies also has not appreciably changed. Typically, the bus system includes flat copper bar conductors for each of three electrical phases, with multiple bars per phase being required to support higher bus ampacity ratings.

## Replacement Considerations

Consistent site maintenance practices to assure both the LV MCC steel structure and the bus system have not been neglected are essential. If one or both has degraded or been compromised over time, replacement of the assembly is recommended. Examples of compromise for these parts of the assembly would be environmental contamination, rust, water ingress, and breakdown of insulation between energized phase conductors or a phase conductor and ground. If the structure and/or bus system is at end of life, replacement is the necessary and recommended option.

Before implementation of a replacement plan, careful project planning is necessary to ensure the project is successful. Consideration of the required time to completely replace existing equipment will impact production. Access to remove the existing assemblies and bring in the new equipment must be considered. One often overlooked issue involved is the cable terminations to existing loads. New assemblies are unlikely to match in location for existing line and load cable terminations. This may require that the project scope include pulling all new cables, which improves overall reliability but adds cost in materials, labor and lost production. If existing outgoing cables to the LV MCC motor loads are run in individual conduits, the conduit condition and the required number of cable bends should be reviewed. If motor cables are routed through an open cable tray, removing existing cables and installing new may present added challenges dependent on the cable routing. Even if existing conductors can be reused, there is risk in disrupting existing terminations that were first made 30–40 years ago. Oftentimes, especially for larger conductors, aged insulation systems can crack and become compromised during a replacement project. This would then require new cable to be pulled and terminated, adding significant labor and materials cost in replacing the original cables.

## Review of Standards Prior to LV Motor Control Center Replacement

As mentioned previously, the manufacturing and test standard for LV MCCs applied in North American markets is UL 845.[1] Although the authors are not suggesting that industry users study the details regarding this standard, being familiar with UL 845 is useful in better understanding the scope and available ratings for this class of engineered electrical assembly. One recently developed standard recommended by the authors is IEEE 1683-2014.[2] The document, titled "IEEE Guide for Motor Control Centers Rated up to and Including 600 VAC or 1,000 VDC With Recommendations Intended to Help Reduce Electrical

Hazards" was recently created by a working group of engineers from multiple manufacturing industries, consultants and manufacturers. Note that this document is an IEEE guide, not a standard. Unlike UL 845, IEEE 1683 does not define specific construction and test requirements or specific features, rather the document addresses considerations around LV MCC installation, considering the site power system and electrical safety criterion. The guide also explains the benefits and limitations of certain LV MCC features, offering guidance around common considerations for particular features. The authors suggest review of the IEEE 1683, as well as References 3 and 4, which offer valuable detail regarding choices and outcomes in selecting a LV MCC based on recent industry applications.

## Life Cycle Extension Considerations

**Overdutied Assemblies —** If the steel structure and bus have been well maintained over the years, upgrading existing LV MCC assemblies can often be a viable alternative. That said, the user will still need to ensure the originally installed assembly is properly rated. Over the course of the last several years, many existing manufacturing facilities in industry have improved working conditions for employees by a renewed focus on electrical workplace safety. Driven in part by improved standards for safety, including NFPA 70E-2018 "Standard for Electrical Safety in the Workplace," an enhanced awareness and recognition of both electrical shock hazards and electrical arc flash hazards has emerged. This standard requires existing facilities to complete and, every five years, update an accurate model of the plant electrical power distribution system. This includes completion of a short circuit, coordination and arc flash study, with the end deliverable being warning labels affixed to each of the "openable" electrical panels that identifies the shock hazard, arc flash hazard, working distance boundaries and appropriate personal protective equipment (PPE) required for persons working on or near the panel while energized. One unintended consequence of these system studies has been a realization of some overdutied electrical equipment in existing plants. LV MCCs have been one of the more prevalent examples of existing overdutied electrical assemblies.

Many of the vintage LV MCCs installed between the 1950s and 1980s have lower withstand, bus bracing and interrupting ratings. Vintage MCCs from this era typically include mechanical bus bracing rated from 35,000 to 50,000 symmetrical amperes. Conversely, today's designs typically have ratings at 100,000 symmetrical amperes. System studies resulting from current modeling of existing industrial facilities might, for instance, result in a system available fault current of 46,300 amperes at a vintage MCC installation of a product installed in the 1960s with a maximum 35,000 rating. Of course, when the facility was originally built, there was not an error in selecting the MCCs to be installed. Instead, over the course of several decades, mill loads and system power sources changed, resulting in what once was adequately sized electrical equipment to now be underrated, or overdutied.

In extending the life of existing LV MCCs in a facility, it's possible to increase the assembly bus bracing and interrupting rating so the MCC can continue to provide safe and reliable operation. Some field service engineering organizations that are typically a service arm of an LV MCC manufacturing company offer the capability of modifying existing bus bracing in order to support higher interrupting ratings. For the user, it is important to select a reputable firm with a solid track record of experience to perform these services. Although it will likely be difficult if not impossible to document that the modified assembly will successfully pass original factory tests, in most cases a software model exists that validates a higher interrupting rating based on engineering calculations. In some cases, when the service organization is from the same supplier as the original supplied equipment, documentation of current or updated bus bracing designs versus the originally installed equipment will be supported by factory testing using bus support insulators as supplied in the current design product.

**Starter and Circuit Breaker Units —** After the structure and bus have been thoroughly inspected and possibly modified to ensure conformance and compatibility with the existing system, individual component ratings must then also be investigated. Beyond the enclosure and bus bar system, the other major component in any MCC assembly is the multiple starter and feeder circuit breaker units that serve various downstream loads. Smaller units are typically withdrawable, connected at the structure vertical bus via power stab connections, while large units tend to be fixed-mounted. Fig. 1 shows the component elements of a starter unit from a vintage MCC assembly that is no longer available. However, replacement units still can be supplied in support of this vintage assembly. As shown in Fig. 1, individual components in the starter unit from the upper left of the image include a circuit breaker, in most cases a magnetic only molded case design, manufactured and tested to UL Standard 489.[5] These devices are typically factory sealed with few replaceable parts. Although routine maintenance of molded-case circuit breakers is important, the topic is beyond the scope of this paper and the authors recommend review of References 6 and 7 regarding best practices in maintaining these components. The next component rotating clockwise from Fig. 1 is the three-phase stab assembly. The stabs consist of spring-loaded copper conductors that connect the starter unit incoming power to the MCC vertical bus bars. Stab assemblies are unique to the original MCC manufacturer and it is critical that this component be ordered as original equipment. Following this is the motor starter, consisting of a magnetically operated contactor and a motor overload protective relay. Most vintage motor overload relays employ one of two antiquated means to protect the AC motor based on overcurrent resulting in excess heat of a resistive element in the phase current path. One of these is a bi-metal element; two dissimilar metals that deflect to engage a trip bar to open a contact to de-energize the contactor. The other is a solder-pot element that includes a melting alloy that again, upon melting, actuates a mechanical movement which in turn de-energizes the contactor. Both deploy three heater coils in each of the three-phase current paths which are sized based on motor full-load amperes. In an overcurrent condition, the heater coil deflects the bi-metal or melts the solder alloy, resulting in a mechanical movement that in turn de-energizes the contactor. Other devices in the image include an internal control power transformer and pilot devices mounted on the starter unit door. The center image shows the complete unit assembly, which also includes unit control and power wiring, control terminals, a handle mechanism to open and close the molded-case circuit breaker, and painted steel "wrapper" used as a means to bolt the unit components together into the common subassembly.

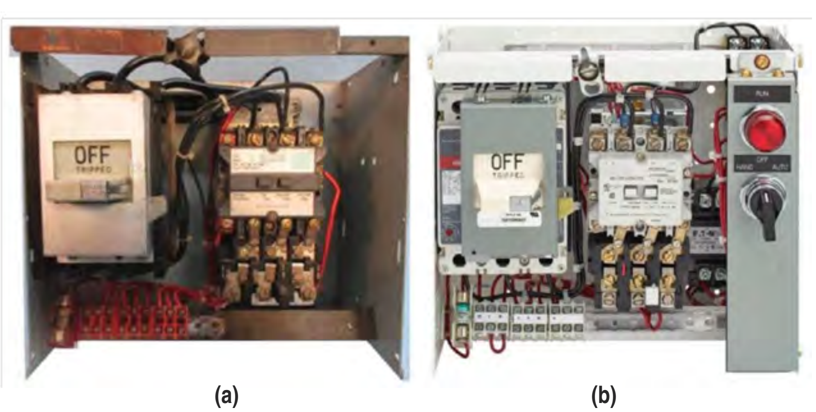
Figure 1


*Components of a low-voltage motor control center starter unit.*

## Upgrade LV MCCs With New Starter and Feeder Breaker Units

Assuming the enclosure and bus system of a vintage low-voltage MCC is in good condition, the most frequently installed and viable method of life cycle extension is replacement of the existing starter and feeder circuit breaker units with new ones. Fig. 3 shows an image of a vintage starter unit from a now obsolete motor control center built in the 1960s next to a new replacement starter unit. Note that the replacement starter unit is a form-fit-function direct replacement for the vintage unit and that the old components have been replaced with new. In some cases, the replacement starter units can include additional components to enhance functionality of the vintage assembly; in this case, a unit-mounted control power transformer and door-mounted hand-off auto selector switch and motor run light addition.

Figure 2




*Vintage design (a) versus current design (b) LV MCC molded-case circuit breaker.*

**UL 845 vs. a Counterfeit Copy —** The UL 845 standard mentioned previously applies to not just newly manufactured motor control centers, but also to replacement starter and feeder circuit breaker units. Just as new units are tested in new control center assemblies, replacement units must also be tested to meet UL 845 test requirements. Electrical testing defined in the standard including heat rise and short circuit tests must be completed while the unit is installed in the MCC assembly. In the case of an obsolete motor control center, new replacement units must be tested in a vintage assembly originally produced by the equipment manufacturer. For a true UL 845 replacement unit, the battery of testing performed is essentially the same as test requirements included for new MCC assemblies. Only after all the tests are successfully completed can a UL 845 label be affixed to the unit, designating full compliance. Over the years, a growing trend has emerged where unauthorized manufacturers have misrepresented replacement starter units to be installed in vintage MCCs as being fully factory tested to UL 845. Shops that specialize in assembling control panels typically offer UL 508 or UL 508A labels affixed to specialty control panels. The UL 508 standard does not apply to motor control centers and does not include short circuit and heat rise testing as defined by UL 845. Users should take great caution in specifying and purchasing MCC units from a reputable supplier, ensuring the UL 845 label is clearly visible and certified test reports are included. Installation of replacement units that have not been properly tested or are assembled with some used components can cause catastrophic failure during a fault, resulting in equipment damage, loss of production, injury or death of personnel.

**Replacing the Circuit Breaker vs. a Complete Starter Unit** — Returning to the topic of the MCC interrupting rating, oftentimes a vintage motor control center will need attention to ensure proper bracing of not only the main horizontal and vertical copper bus, but also the components included in the starter unit itself. As previously discussed, most vintage molded-case circuit breakers typically have lower interrupting ratings and upgrade of this component also needs to be considered. Like the power stab assembly, it is important to consult with the original equipment manufacturer or a qualified electrical services organization to investigate the viability of an MCC upgrade using circuit breakers with higher interrupting ratings. Not just the breaker rating but also the size and form factor must be considered. The starter unit door-mounted handle mechanism will typically be mounted on the circuit breaker so the location and movement of the circuit breaker handle must be compatible with the door-mounted mechanism. Regarding installation of new molded-case circuit breakers with higher ratings than the legacy devices, in some cases, the original equipment manufacturer's current offering will be available in higher current and interrupting ratings. Fig. 3 shows a current design molded-case circuit breaker versus one from nearly 50 years ago. Note that the new offering includes features such as finger-safe terminals and a push-to-trip test button, available as standard with a 65,000-symmetrical-ampere interrupting rating. Although the form factor and breaker-operating handle location for the vintage and new circuit breaker are identical, simply installing the new breaker in place of the old is not recommended. The issue here is that the interrupting rating of the subassembly is based on the combination of the circuit breaker and the motor starter functioning together. The UL 845 test defines this combination rating. As previously mentioned, vintage magnetic starters have traditionally used heater coils for motor overload protection, offering an impedance path to limit fault currents during short-circuit conditions. This limitation gives the circuit breaker magnetic trip element time to actuate and successfully clear the fault. New magnetic starters nearly universally apply onboard current transformers with sophisticated electronics to sense motor overload and a host of other abnormalities to protect the motor and driven load. In the absence of the additional resistance from the vintage heater coils, the circuit breaker may not successfully clear a higher-level fault. As defined in the UL 845 standard, both the circuit breaker and the motor starter/protective relay are interdependent and must be tested together.

Figure 3


(a) (b)

*Vintage design (a) vs. current design (b) LV MCC molded-case circuit breaker.*

**Technology Advancements in Motor Protection** — Over the past several decades, advances in electronics have accelerated the functionality of overcurrent circuit-protective devices and compact adjustable frequency drives (AFDs) are now routinely installed in low-voltage motor control centers. Current design motor overload relays have evolved to function as intelligent motor-protective devices that continuously monitor positive and negative sequence motor phase currents to establish a precise thermal model of the machine's windings. These deliver an order of magnitude of improved motor protection and functionality. Recent papers including Reference 8 discuss case histories involving low-voltage motor control center installations where new motor management relays with enhanced functionality have been installed. The latest offerings include advanced protective features in a small, network-communications-ready package. Referring to Fig. 4 as a typical current design device, a measurement module includes integral current transformers, allowing three-phase power conductors to connect between the switching contactor and three-phase motor terminals. Voltage terminations are also made at the base module that support functionality beyond legacy motor-protective relays including undervoltage, underload and pump cavitation, along with metering of phase voltages, amperes and power in watts and vars. A base control module communicates new available data via a host of communication networks, the most prominent in industry today being Ethernet/IP. An optional user interface module is also used for local control and monitoring as desired.

Figure 4


*Typical microprocessor-based motor management relay.*

One important added capability of the onboard microprocessor of the base control module is the ability to locate a grounded motor feeder in a high-resistance pulsing ground system.[9] Since the measurement module of each relay includes three integral current sensors, special functionality of the new relay has been added to recognize when the high-resistance grounding (HRG) pulser has been activated and then report not only which motor feeder but also which phase of the faulted feeder has a ground fault. This new functionality greatly reduces added complexity in current design HRG systems that employ additional zero-sequence current transformers (ZSCT) wired back to a HRG relay at each individual motor starter unit in the LV MCC as discussed in References 10 and 11.

Application of the latest designs of these motor management relays deliver a step-change in motor protection versus legacy controls installed in vintage equipment. More importantly, the availability of real-time data measuring phase currents and voltages for every driven load offers a new platform of functionality that will be transformative for industry. Without question, the added capability of network connectivity can serve as an enabler to ensure any existing industrial plant, even a plant with 40- to 50-year-old legacy electrical systems, can be positioned to compete with new plants utilizing the latest technologies. Industry users can utilize network-enabled systems to deliver an abundance of available data and extract useful information to improve system reliability, uptime, efficiency and safety. Today's fourth industrial revolution is characterized by a transition from the manual, sequential value chain in manufacturing to an information-rich digital core enabled by new developments in smart sensors, cloud computing and the Industrial Internet of Things (IIoT). A number of existing industrial plants, including some from the authors' company, have recently completed successful life cycle extension projects including upgrades of LV MCCs and other electrical power distribution and control assemblies. These have clearly leveraged the latest in network-enabled systems, offering a platform in support of the coming new era of digital transformation.

Table 1 offers suggested decision criteria in reviewing the available options to replace or upgrade existing low-voltage MCCs as discussed in this section.

## Conclusions

Existing steel mills in the process industries need to consistently focus on maintenance of aging assets to ensure electrical systems continue to operate both safely and reliably. There are many existing facilities first commissioned 40 to 50 years ago where existing systems are approaching end of life. The need for

## Table 1

*Decision Criteria for Replace vs. Upgrade*

| Alternative | Initial cost | Installation cost | Cost to maintain | Reliability/ maintainability | Required downtime |
|---|---|---|---|---|---|
| Replace existing assembly | High | High | Low | Maximized | Very high |
| Upgrade existing assembly rating | Moderate | Moderate | High | Minimal | High |
| Refurbish existing LV MCC starter units | Low | Moderate | Moderate | Minimal | High |
| New LV MCC starter units | Moderate | Low | Low | Maximized | Lowest |

continuous improvements in operational productivity requires a focused effort to analyze which systems must be replaced versus which can be upgraded. Existing low-voltage MCCs with structure and bus systems that have been well maintained represent potential opportunities for upgrade versus replacement. The user should consider original equipment ratings to ensure sufficient interrupting capacity for the application. Also, a working understanding of the UL 845 standard is recommended prior to execution of any project involving upgrade of an existing motor control center. With developments in technology, there are many opportunities to enhance the functionality of existing assemblies as a part of any upgrade project. Looking forward, plants will need to leverage network connectivity and find ways to take advantage of a newly realized wealth of readily accessible digital data, extracting the right information necessary to improve operations. This will involve more than just adding technology to the existing model. Instead, true digital transformation will likely involve the much more difficult task of rethinking the current business model and applying this to a new platform supported by 21st-century technologies. The path forward in many cases will not require a wholesale changeout of existing systems, which is both cost prohibitive and simply impractical. Instead, a carefully planned program to upgrade existing systems is often a valid approach. Early alignment with key equipment suppliers and contractors to build a business case to review the replace versus upgrade alternatives followed by installation of network-enabled systems can position any existing manufacturing business to move forward toward their digitalization transformation future.

## References

1. UL 845, "Motor Control Centers," Underwriters Laboratories, Northbrook, Ill., USA.
2. IEEE 1683-2014, "IEEE Guide for Motor Control Centers Rated up to and Including 600 VAC or 1000V DC With Recommendations Intended to Help Reduce Electrical Hazards."
3. Valdes, M.E.; Bugaris, R.M.; and Wellman, C.M., "The Making of IEEE 1683 — An Introduction and Behind the Scenes Look," *2015 IEEE IAS Petroleum and Chemical Industry Technical Conference,* pp. 1–8.
4. Sauve, T.R.; Anderson, R.P.; Bower, T.; and Mickler, K.R., "Designing and Specifying MCCs to Reduce Hazards and Risks, Using IEEE 1683," *IEEE IAS Petroleum and Chemical Industry Technical Conference,* 2017, pp. 387–396.
5. ANSI/UL489 Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit-Breaker Enclosures, 2016.
6. IEEE Standard 1458 Recommended Practice for the Selection, Field Testing, and Life Expectancy of Molded Case Circuit Breakers for Industrial Applications, IEEE IAS 2005.
7. Higginson, M., and Durocher, D.B., "Proper Application and Maintenance of Molded Case Breakers to Assure Safe and Reliable Operation," *IEEE IAS Pulp and Paper Industry Technical Conference,* 2009, pp. 102–113.
8. Durocher, D.B.; Hussey, M.R.; Belzner, D.; and Rizzi, L., "Application of Next-Generation Motor Management Relays to Improve System Reliability in Process Industries," *IEEE Transactions on Industry Applications,* March/April 2019.
9. Beltz, R.D.; Peacock, I.; and Vilcheck, W., "High-Resistance Ground Retrofits in Pulp and Paper Mills," *IEEE Industry Applications Magazine,* 2001, Vol. 7, No. 2, pp. 19–27.
10. Bapat, A.; Hanna, R.; and Panetta, S., "Advanced Concepts in High-Resistance Grounding," *IEEE IAS Petroleum and Chemical Industry Conference,* 2012, pp. 1–9.
11. Locker, A.S., and Scarborough, M.S., "Advancements in Technology Create Safer and Smarter HRG Systems," *IEEE IAS Pulp and Paper Industry Technical Conference,* 2009, pp. 102–113. ✦

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# New Advancements in Condition Monitoring Technology to Enhance Steel Mill Productivity and Profitability



## Authors

Toby Hlade (left)
grease technical advisor – Americas, Mobil Industrial Lubricants, Spring, Texas, USA
toby.hlade@exxonmobil.com

Timothy Hurley (right)
head of plant engineering, Primetals Technologies Ltd., Worcester, Mass., USA
timothy.hurley@primetals.com


Steel mill operators have long used condition monitoring to deliver critical, real-time equipment performance insights that can help reduce unscheduled downtime and maximize productivity. However, as condition monitoring programs continue to incorporate newer technologies, operators can gain even deeper insights that further improve equipment operation and maintenance decisions. Leveraging field and laboratory data, this paper will delve into some of these new technologies, including in-line oil sensors, and discuss how they can be integrated into a modern predictive maintenance program to deliver productivity and cost reduction benefits to steel mill operations.

Steel mill applications place enormous stress on equipment components, including heavy loads, extreme high temperatures and near-continuous water exposure. To ensure proper protection and minimize the potential for unscheduled downtime, operators need a finely tuned lubrication strategy. Specifically, operators should leverage newer condition monitoring technology that provides equipment behavior trends to better withstand extreme conditions and maximize equipment productivity. Leveraging laboratory and field data, this paper closely examines the latest advancements in condition monitoring technology and highlights how operators can take advantage of insights delivered by these platforms to make better-informed decisions and enhance equipment performance in these high-stress environments.

## Discussion

**The Evolution of Condition Monitoring Technologies** — The steel industry is one where equipment operates under severe stress, extreme temperatures and heavy load conditions on a regular basis, posing a range of equipment maintenance challenges that — if not properly addressed — can limit productivity and profitability.

For example, steel mill systems operate under high and variable speed and load, with hundreds of bearings, gears, shafts and additional components. In these complex systems, how can operators detect developing defects at an early stage and measure defect severity? Furthermore, how can operators better match maintenance activities with the real conditions of the equipment, moving more toward a predictive maintenance approach rather than a reactive one?

To complicate matters further, many steel mill maintenance teams face limited resources and budget, so how can all maintenance be planned maintenance, and how can those teams eliminate surprises to maximize resources?

And, perhaps most important to the overall success of the steel mill, how can operators extend machinery life or increase throughput without risk of machine failure to stay competitive even when using older or high-duty equipment?

One of the most effective solutions to tackle these important issues is implementing a robust condition-based monitoring program that takes advantage of the latest technologies. Based on an analysis conducted by Primetals Technologies, the most effective maintenance programs spend 80% of the overall budget on predictive and preventive maintenance programs (which includes the use of condition-based monitoring technologies). Unfortunately, however, the same analysis found that most steel facilities spend 80% of their resources on reactive maintenance activities — meaning many operators are not taking the right steps to maximize their productivity.

The benefits of predictive and preventive maintenance programs are proven. For example, an iron and steel company in China was experiencing abnormal wear in the gearboxes of its 16 sets of conveyers, and they frequently conducted oil changes on a reactive basis to address the issue. However, after accepting a recommendation to conduct routine used oil analysis, technical experts discovered that the lubricant in the conveyers was unable to withstand the harsh operating conditions. The plant then switched to a synthetic lubricant formulated to provide high-temperature oxidation stability, which helped reduce average operating temperature by 7.6°C, in turn reducing the wear abnormalities. Making the switch also helped the company extend oil drain intervals and improve energy efficiency. Together, these insights helped the company save US$1,830 annually.

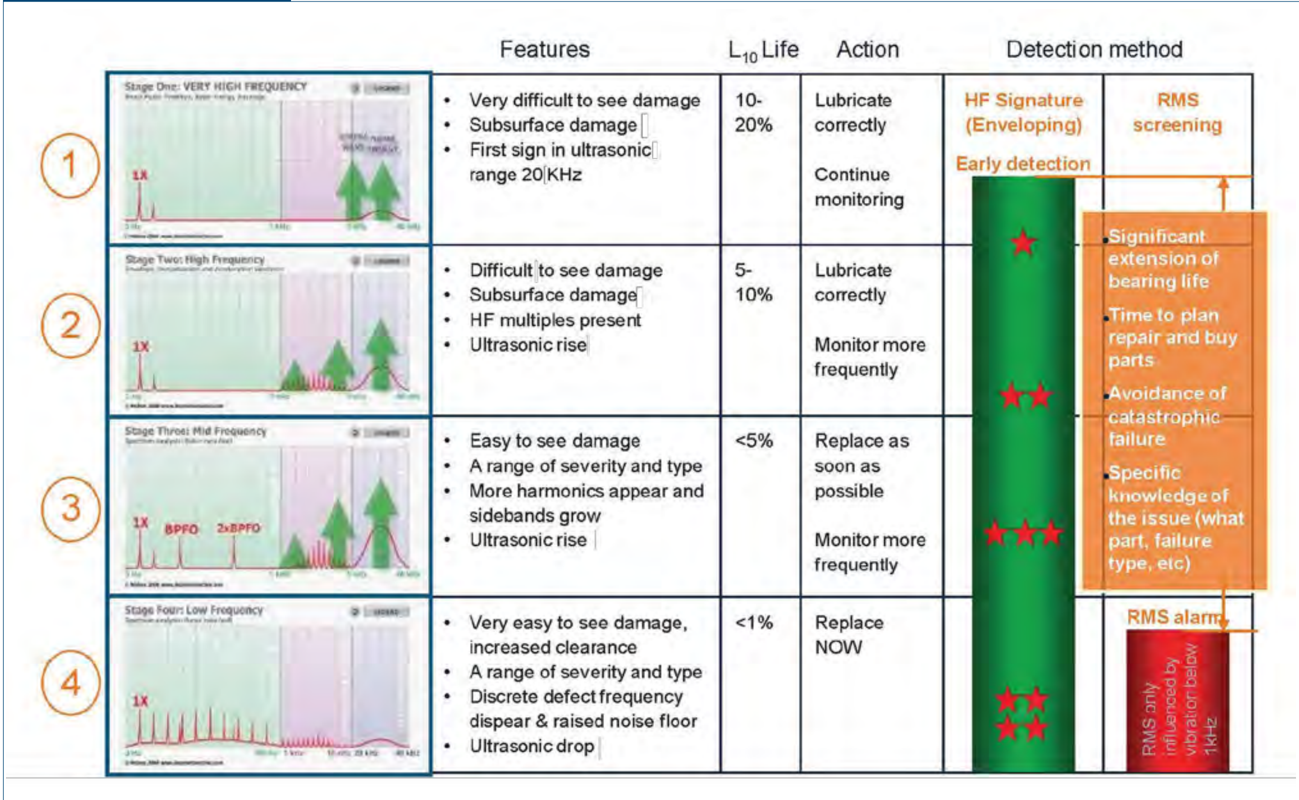
Condition monitoring as a practice is not new. In fact, many condition-based monitoring tools have been around for decades. However, advancements in these tools are providing operators with new opportunities to monitor equipment performance in real time and address equipment performance issues before they become a problem.

**The Power of Real-Time Condition-Based Monitoring** — In today's production environment, even the shortest amount of downtime can result in millions of dollars of costs, so being able to act and address an issue before it becomes a problem is vital.

For example, consider Fig. 1, which shows how real-time insights from vibration analysis can provide operators with advance warning of bearing failure (more to come on vibration analysis later on).

As seen in this chart, a condition-based monitoring tool such as vibration analysis can detect issues before they become visible and provide operators with an understanding of what action they should take to resolve the potential performance issue. Replacement components such as bearings are very expensive,

## Figure 1




*The four stages of bearing failure, ranging from subsurface-level pain points to severe damages noticeable to the human eye. The chart also indicates how vibration readings can help pinpoint which stage of failure the bearing is currently experiencing.*

especially when one considers the associated downtime for the entire machine.

To drive this point home, Fig. 2 outlines the cost benefit of a robust preventive maintenance program, referencing several commonly used technologies.

This paper will now explore the various condition-based monitoring tools available today and how their insights, when analyzed holistically, can help operators build a best-in-class predictive maintenance program.

**Condition-Based Monitoring Technologies for Assessing Equipment Condition —** There are various sensor technologies available that measure critical characteristics related to equipment performance and condition, including vibration, temperature, amperage and pressure.

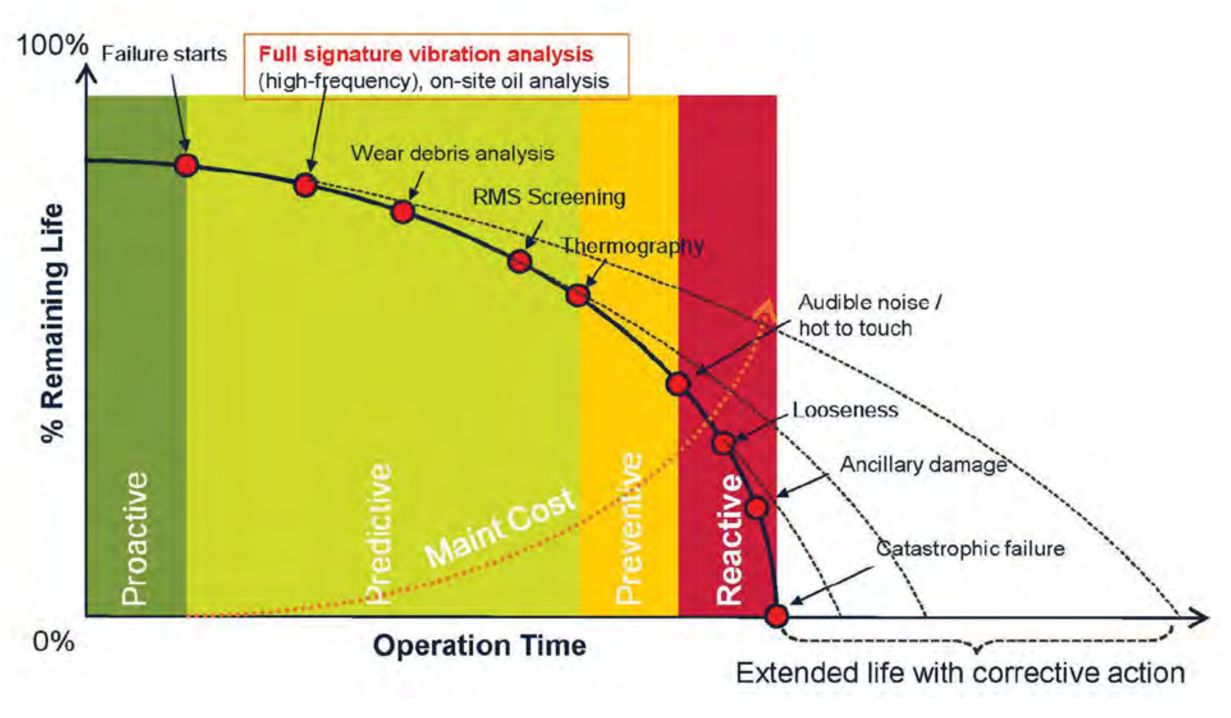
**Vibration Sensors:** Vibration analysis is one of the most important condition-based monitoring tools in any steel mill operator's arsenal. It can provide insight into the performance of motors, gearboxes and pinion stands across an operation. It can help detect issues such as early roller bearing degradation, coupling misalignment and looseness, mechanical looseness, gear wear, worn or broken gear teeth, improper lubrication, worn seals, and electrical problems.

But, not all vibration sensor technologies are created equal. Today, many sensor technologies measure root mean square (RMS) amplitude. Though this method is an ISO convention, measuring vibration in this way may not give operators a full picture of what is happening inside their equipment.

Instead, there are vibration sensor technologies available that can deliver a full signature analysis, which can provide a much more complete perspective. Consider the following example.

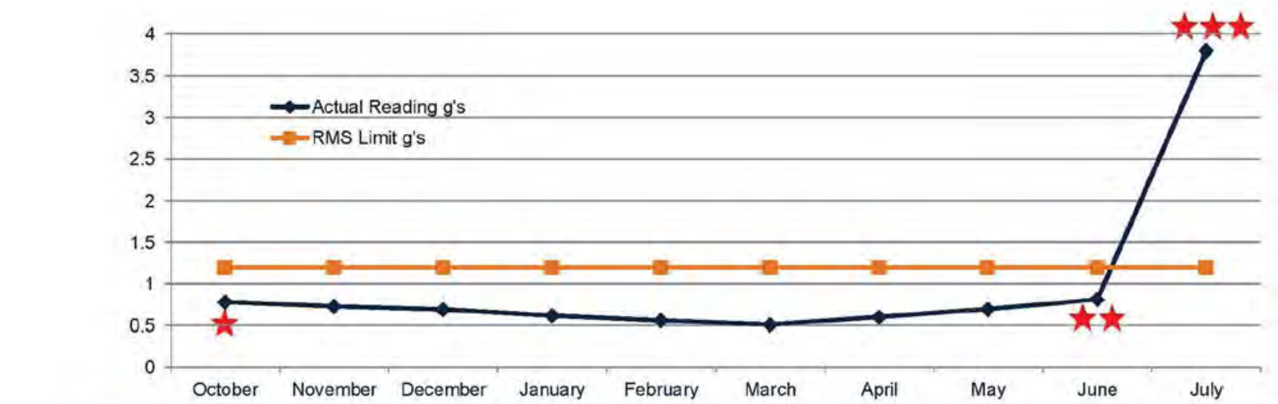
One steel manufacturer was conducting a side-by-side comparison of a RMS-driven sensor analysis program and a full signature analysis program. At one point, the full signature analysis program detected a possible issue with a bearing because of defect frequency harmonics. The RMS program did not flag any alerts, but the customer nonetheless ordered a replacement bearing. The customer continued to monitor the bearing continuously. Eight months later, the full signature analysis program flagged an increase in bearing frequency noise, indicating a more significant issue on the degrading bearing. At this time, RMS readings continued to remain below the trigger limit, so the other program did not send out any alerts. Only one month later, the full signature program detected a 350% increase in amplitude, indicating imminent failure. The operator scheduled

Figure 2




*The cost benefits of implementing a predictive maintenance program. Many basic monitoring tactics, while somewhat insightful, do not provide enough real-time insights to help operators address equipment performance issues well before they result in failure.*

## Figure 3



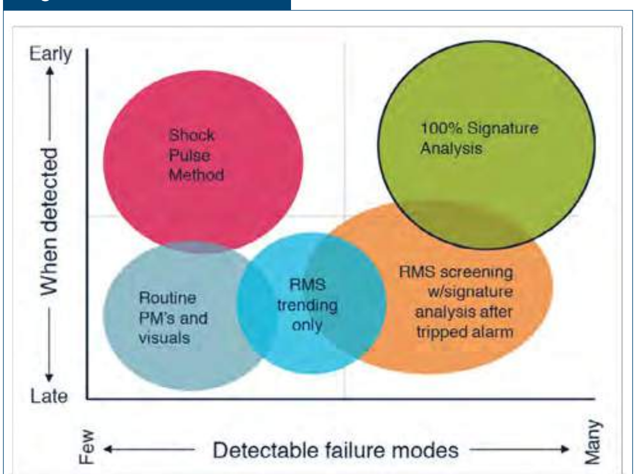

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Competitor Report | OK | Ok | Ok | Ok | Ok | Ok | Ok | Ok | Ok | Alarm |
| **Primetals Report** | 1 star bearing OR defect frequency harmonics found | Monitoring | Monitoring | Monitoring | Monitoring | Monitoring | Monitoring | Monitoring | 2 stars bearing frequency noise raised | 3 stars 350% amplitude increase |
| Customer | Order bearing | | | | Bearing in stock | | | | Shutdown scheduling | Bearing replaced |

*Comparison of the results of the full signature analysis program with the root mean square (RMS) analysis program. The full signature analysis program delivered alerts well before the RMS program flagged a potential problem.*

a bearing change during a planned outage the following month. The RMS reading finally triggered an alert, but the alert would have been far too late. The operator estimated that the full signature analysis program saved the company six to eight weeks of unscheduled downtime.

This is just one example illustrating the power of newer vibration sensor technologies and their potential. For easy reference, Fig. 4 and Table 1 outline the

## Figure 4




*The capabilities of signature vibration analysis compared to other traditional vibration monitoring methods.*

## Table 1

***Equipment Issues That Can Be Detected by Full Signature Vibration Analysis***

| Failure mode | Full signature | RMS trending | Shock pulse | Human being |
|---|---|---|---|---|
| Imbalance | ✓ | ✓ | ✗ | ✗ |
| Coupling misalignment | ✓ | ✗ | ✗ | ✗ |
| Overall looseness | ✓ | ✓ | ✗ | ± |
| Early bearing defects | ✓ | ✗ | ✓ | ✗ |
| Gear defects (wear/broken teeth) | ✓ | ± | ± | ✗ |
| Improper lubrication | ✓ | ✗ | ✗ | ± |
| Electrical-related faults | ✓ | ✗ | ✗ | ✗ |
| Belt problem | ✓ | ✗ | ✗ | ✗ |
| Vane/blade pass | ✓ | ✗ | ✗ | ✗ |
| Caviation/recirculation of pumps | ✓ | ✓ | ✗ | ✗ |
| Resonance | ✓ | ✗ | ✗ | ✗ |
| Sleeve bearings | ✓ | ✗ | ✗ | ✗ |

value of full signature analysis compared to other common vibration programs.

Much of today's critical steel equipment is already pre-equipped with vibration analysis capabilities, but operators can consult their original equipment manufacturer (OEM) partners to assess whether they have the latest vibration analysis technologies in place.

**Temperature Sensors:** Operating temperature is often one of the most accurate indicators of whether a system is performing as it should. An abnormal increase in temperature is typically a sign that something is wrong. Today's temperature sensors can even alert operators when lubricant temperature changes within ±0.5°C.

When connecting this data with other lubrication related data such as vibration and oil analysis, temperature trends are helpful when confirming the condition of active lubricant.

**Motor Amperage:** Motor amperage is a good indicator of overall system health on motor-driven equipment. Increases in amperage draw are expected with changes in machine loading, but also occur with changes in lubrication performance and lubricated component health within these systems. If baselines are established to subtract normal loading variation, then lubrication and equipment health impacts can be seen more clearly. Motor amperage is often tracked for very large drive systems but can be added to smaller systems of critical importance. Combining this data with other lubrication-relevant data can provide a more complete picture of system performance.

**Monitoring Fluid Condition** — Lubricant is another critical component to monitor. Lubricants are the lifeblood of any industrial machine, particularly for equipment that operates in conditions such as those in a steel mill environment. When mill fluid systems are operating at optimum performance levels, they can help improve product quality and yield, enhance safety, and reduce operating costs.

In order to ensure these systems are running as efficiently as possible, operators should build a condition-based lubricant monitoring program that incorporates the latest sensor technologies. A good program should be able to regularly monitor key characteristics, including lubricant quantity (component requirements vs. pumping capacity), cleanliness (filtration and water removal) and temperature (cooling/heat control).

There are three key steps to building any good program:

- Auditing a plant's current program: The first step to implementing an analysis program is to identify consistent fluid system issues. Lubricant and OEM partners can often identify pain points in a current program and identify technology to help enhance equipment reliability. Most audits focus on lubrication systems and cooling lines.
- Designing a revamped analysis strategy: OEM and lubrication partners leverage their experience and capability to help the operator update or revamp the design of their rolling mill and fluid system maintenance program to deliver more predictive insights.
- Installing new technology: OEM partners can often install these new tools into existing systems on behalf the operator, including piping and flushing supervision. In addition, these partners may offer on-site personnel trainings and can troubleshoot existing systems in place.

**Condition-Based Monitoring Technologies for Fluid Analysis** — It is estimated that 70% of component replacements in mills are caused by surface degradation and/or wear on said component. In hydraulic and lubricating systems, 50% of these replacements are the result of mechanical wear, with another 20% resulting from corrosion. There are a number of strategies to help keep these types of issues to a minimum, specifically by understanding lubricant condition.

There are a range of valuable monitoring technologies that can help provide critical insights into lubricant condition.

**Routine Used Oil Analysis:** Used oil analysis is a tried-and-true method to deliver regular insights into the performance of both the equipment and the lubricant itself:

- Equipment condition — Used oil analysis reports can provide insight into equipment wear and help understand the metallurgy of the components being tested. For example, used oil analysis may reveal the presence of high levels of copper, which indicate the gear is out of alignment. If caught early enough, operators can potentially save costs due to unplanned downtime and extensive repairs.
- Lubricant condition — Keeping strong lubricant performance requires the formulation to maintain its physical properties. However, as a lubricant continues to be exposed to severe conditions, this can alter its properties and cause viscosity changes that affect equipment performance.

Operators should conduct oil analysis on a routine basis to measure these characteristics and identify trend lines. A single alert does not necessarily indicate a performance issue, but when a trend emerges, it's a sign that it's time to act.

Conducting this analysis on a routine basis is also getting easier with new technology. Some used oil analysis technologies have recently incorporated "scan-and-go" functionality that utilizes QR-coded labels to more easily "tag" the sample — allowing for a paperless process. With this system, operators can enter analysis data into an online system.

**Water Sensors:** Steel mill applications are exposed to enormous amounts of water throughout the manufacturing and finishing processes, but water can be a dangerous contaminant. When metal components are left unprotected, water can accelerate wear, corrosion and lubricant degradation (Fig. 5).

Lubricants used in steel mill applications are specifically designed to separate from water, but water contamination can still occur. To help prevent this contamination, there are sensors designed to monitor water contamination in the lubricant.

In-line humidity-based sensors have been available for some time and at a reasonable cost, but these technologies are typically limited to absorbed water saturation and measure a few hundred parts per notation for industrial oils. This makes them best suited for dry systems that are periodically exposed to contamination.

Newer sensor technology has the ability to detect and measure both emulsified and free water, which is more appropriate for traditionally wet systems associated with steel equipment. Today, many operators use water sensors in the drain lines of every Clevite bearing in order to alert the user when potential water ingress enters the system.

**Dielectric Constant Sensors:** Oxidation or contamination can change oil chemistry, affecting the dielectric constant of an oil and causing it to be less effective in equipment over time. Dielectric constant sensors are an inexpensive condition monitoring tool for continuous monitoring, as they'll indicate when the oil chemistry has changed, but, even though they do trigger an early warning, they are limited in that they cannot pinpoint specific issues or accurately diagnose equipment failure.

**In-Line Viscosity Sensors:** Viscosity is one of the most important characteristics of an oil. An oil needs to be able to maintain a certain viscosity in order to minimize metal-to-metal contact and keep the system running as needed. Extreme conditions can degrade the oil, which can in some cases change its viscosity. That's why viscosity sensors are a critical tool that provide data that measures viscosity in real time. Any significant change indicates that there is a performance issue that needs to be addressed.

Figure 5

*Acid etching on a work roll bearing, which was caused by water contamination.*

Given the severe conditions associated with steel equipment, these viscosity sensors are designed to be unaffected by shock or flow changes.

**On-Line Particle Count Sensors:** Water contamination is not the only contamination-related danger for steel mill equipment. Other particles, such as wear metals, dust and more, can pose a serious risk to equipment when they enter the system. Contaminants can enter the system through a variety of means, including from metal wear, pre-contaminated oil from changeout or from external elements during a maintenance process. To properly measure this issue, operators can use on-line particle count sensors, which assess the level of contaminants in gear oils, hydraulic systems and metal processing systems. There is typically a certain threshold for contaminants (measured in parts per million), and sensors can trigger alerts when that threshold has been exceeded.

**Fourier Transform Infrared Spectrophotometry (FTIR):** One of the most commonly used tools in an oil analysis lab, FTIR measures the absorption of infrared light at various wavelengths to create a chemical fingerprint of the oil. This can detect signs of lubricant contamination and degradation. In used oil analysis, it is commonly used to detect water, oxidation, nitration and other contamination.

While this tool has historically been restricted to the lab due to sensitivity and cost, technology is evolving to become more simplified. Some units are now on the market that bring this technology to in-plant or even in-line capability.

**Monitoring Technologies to Help Prevent Leakage —** Lubricant leakage is a difficult — and unfortunately common — challenge for many mill operators. Older equipment, in particular, is prone to leakage as a result of the intense operating conditions. Leakage causes higher oil consumption and is more likely to cause equipment wear due to improper lubrication.

One technology that can help address this challenge is a meter that measures leakage rates in lube storage tanks. There are also several other sensors that can help identify leakage and its source:

- Fill point meters — These simple meters are attached to the fill point on major reservoirs, providing accurate measurements of oil consumption. These can be read manually or wired to a central monitoring platform for direct feedback.
- Tank level monitors — Large tanks can see significant swings in lubrication levels through the course of operation. Tank level monitors can help operators regulate leakage levels in large hydraulic and lubricating systems. They typically sound alarms when significant changes in consumption are recorded.

Since leakage often indicates impending equipment failure, using monitoring technologies can help operators get ahead of a potential problem.

**Integrating Data Insights to Build a Complete Equipment Performance Profile —** This paper has outlined a range of condition-based monitoring technologies that can give steel mill operators valuable insights to help enhance productivity and profitability. But, simply installing a sensor and using it in isolation provides marginal value.

A best-in-class preventive maintenance program incorporates numerous condition-based monitoring processes to build a complete profile of equipment performance. Each sensor provides its own valuable data point, and when analyzed in aggregate, this information can provide enough context for an operator to understand what action to take to prevent a failure mode. More importantly, building this complete picture can help operators even extend equipment life or safely increase the production rate beyond the status quo, helping them deliver even more value to the operation.

To learn more about these technologies and to build a robust predictive maintenance program, operators should consult with their OEM and supplier partners.

## Conclusion

Understanding real-time equipment performance is essential for achieving productivity and efficiency goals, especially as operators strive to increase their production goals. By adopting the latest, most advanced condition-based monitoring technologies — and building a holistic program that aggregates their insights — operators can make more informed maintenance decisions that will reduce downtime, enhance productivity and ultimately increase profitability. ✦

This paper was presented at AISTech 2019 — The Iron & Steel Technology Conference and Exposition, Pittsburgh, Pa., USA, and published in the Conference Proceedings.

## Did You Know?

### Salzgitter Takes Next Step in Hydrogen Project

Salzgitter and industrial partners Rhenus and Uniper will explore the feasibility of building a direct reduced iron plant and associated hydrogen electrolysis plant at a deepwater port in northern Germany, the company announced.

"This is another concrete step in our process of evolving toward low-$CO_2$, hydrogen-based steel production underpinned by our prestigious Salzgitter Low-$CO_2$ Steelmaking technology concept. Once this step has been realized, we will be making a decisive contribution to achieving the climate targets," said Salzgitter AG chief executive Heinz Jörg Fuhrmann.

Salzgitter said it is considering the port of Wilhelmshaven in Lower Saxony as the home for the facility.

"Together with our local industrial partners, the Wilhelmshaven site offers very favorable preconditions for an optimal sector coupling of renewable energies for hydrogen electrolysis and the low-$CO_2$ direct reduction of iron ore," said Fuhrmann.

The company said it plans to wrap up the study by next March.

# Reparation of Trusses in Steel Plant Environment

Authors

José Geraldo de Araújo Silva
(pictured)
Metalcon, Ipatinga, MG, Brazil
jgaraujo@gmail.com

Antonio Maria Claret de Gouveia
Universidade Federal de Ouro Preto, Ouro Preto, MG, Brazil
claret@em.ufop.br

Hisashi Inoue
Universidade Federal de São João del-Rey, Ouro Branco, MG, Brazil
hisashi@ufsj.edu.br

Gustavo Oliveira Daumas
Universidade Federal de Ouro Preto, Ouro Preto, MG, Brazil
godaumas@gmail.com

Lucas Teixeira Araújo
Universidade Federal de Ouro Preto, Ouro Preto, MG, Brazil
lucastexeira32@gmail.com

In an competitive world, where the growing need to develop industrial production/productivity requires maximum performance, new technologies and equipment are required. Thus, reinforcement/retrofit of structural elements is needed. After some years, a structure can present pathologies that can be caused by new loading, design/assembly/fabrication deficiency or even lack of maintenance. Therefore, when it is necessary to accommodate new loads, it is crucial that the proposals contemplate the new loadings and a good structural condition. This paper reports on field experience during the work of repowering trusses with almost 20 years of use in an extremely aggressive environment.

In an increasingly competitive world, where the growing need to develop industrial production/productivity requires maximum performance, new technologies and equipment are demanded. Thus, in cases of increased industrial performance, there is a need for reinforcement/recovery of structural elements, since these were not initially designed to absorb the new efforts. However, in cases where the maintenance has left something to be desired (or been lacking completely), various pathologies may arise, causing not only the need for structural reinforcement, but also for correction.

After some time in use, a structure can present several pathologies that can be caused by new loading, dynamic actions, design/assembly/fabrication deficiency or even lack of maintenance (mainly). Therefore, when it is necessary to accommodate new loads, it is crucial that the proposals contemplate not only the new loadings and their combinations, but also the structural condition of elements involved in this stage.

Structural retrofit, whether due to the need to allocate new equipment and/or correction, is becoming very common today. For this reason, the structural engineer must be aware of the reasons that lead to the need for structural reinforcement, as well as being aware of technological advances in terms of materials and calculation methodologies.

The present case is a space truss system formed by four units, two vertical (main) and two horizontal (secondary) responsible for the horizontal stabilization of the system. Some specialized literature calls this structural system a lattice tunnel.

The structure is part of a set of conveyors in a large steel industrial complex in northern Brazil and is responsible for the transportation of corrosive material between two plants. The chemical element sometimes falls from the conveyor belt and is housed at the lower part of the structure (on the flange profiles, on the horizontal trellis parts and especially on the links). Since the cleaning of the structure as well as the removal of the materials falling from the belt are difficult to carry out and there is constant discussion between maintenance and production personnel, the corrosive process has started and luckily did not bring the structure to break.

Due to the need to place new equipment and increase the capacity of the conveyor belt, the system was completely stopped and a general inspection was carried out in this structure, where there was widespread corrosion, excessive deformation of structural elements (secondary and primary) and broken connections.

The vertical trusses are Pratt type and the horizontal trusses are K type. The dimensions of the structure are:

- Span: 118 feet (36 m).
- Distance between verticals: 9 feet 10 inches (3 m).
- Distance between vertical trusses: 13 feet 1 1/2 inches (4 m – center to center of profiles).
- Height of vertical trusses: 9 feet 10 inches (3 m – center to center of profiles).
- Type of support: isostatic (roller).
- Type of connection in verticals and cords: pinned.
- Adopted profile on flanges: welded steel profile ASTM-A36.
- Profile adopted on diagonals and verticals: double angle in steel ASTM-A36.
- Connection plate (gousset): 3/8 inch (#9.7 mm).
- Screws: A325N (cutting plane passing through the thread).

The dimensions are shown in Figs. 1 and 2.

Based on the data obtained from the existing projects, the structure was checked, under the conditions in which it was originally designed, with the proposed overloads (equipment, materials and wind according to NBR6123). Using MCalc3D software and the standard NBR8800, the structure was analyzed and the most requested bars were found, as well as the maximum deflexion, whose values are:

- Bar most requested: diagonal compressed with 80% of use.
- Maximum deflexion: 3 1/8 inches (80 mm), at span center (L/450), when the maximum load was acting.

## Discussion

Based on the theoretical data, the current status of the structure was verified in the field, so that the new study could be carried out. The indications were loss of material because there was a marked deformation near one of the supports and the material which is carried by the belt has a pH of around 4.

Also, it should be noted that in its 40 years of existence, the structure has never undergone severe maintenance. It is imperative that in all production sectors that the maintenance and production teams work in harmony, since the absence of effective maintenance can bring premature equipment wear and leaves a gap for accidents. Otherwise, a large time demand may cause production loss and delay compromise.

During the inspection, several non-conformities were found, such as:

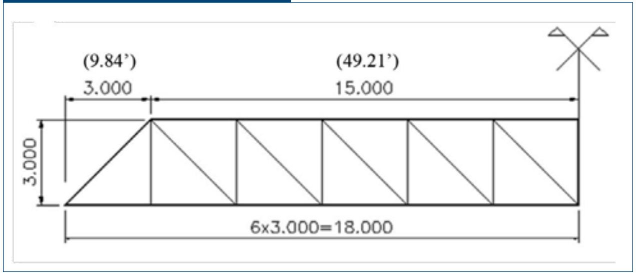
- Connections broken or without effectiveness.
- Corrosion in main bars.
- Corrosion on secondary bars.
- Vertical bars and diagonal bars damaged.
- Vertical bars and diagonal bars with part of the ruptured section.
- Excessive deformation.
- Warping in runway beam.

Fig. 3 shows some of these pathologies.

Retrofit is a term used mainly in engineering to designate the process of modernization of some equipment or structure already considered outdated or out of standard. In the present case, the reengineering was carried out to contemplate both proposals, since the standard used for calculation was NB14 (allowable stress method), in use at the time of fabrication of the structure and that when the improvements in truss the current norm was NBR8800 (load and resistance factor design), which is in use today.

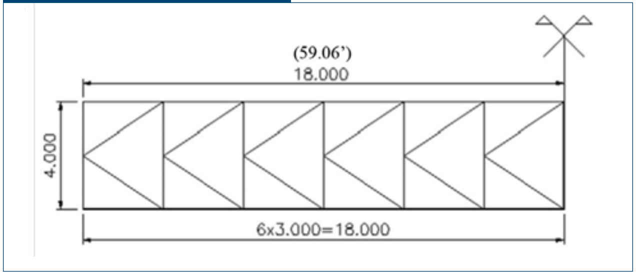
In order to attend to the normative requirements of safety and use, repairs were made (change of structural parts, parts of profiles and connections) and

Figure 1



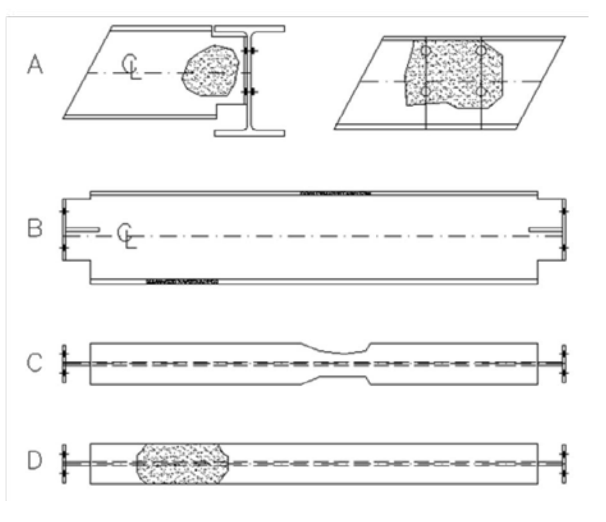

*Side view of the main truss (vertical). The vertical and diagonal bars are in angles opposed by vertices and chord and the first diagonal are in built-up profiles (welded profile).*

Figure 2




*Top view of upper truss (horizontal). The chords are common to this truss and to the main trusses (vertical). The diagonals are in double angles opposite by vertices. The verticals are in built-up profiles (welded profile) and in upper truss these are requested to bend because the loads of equipment are in these pieces.*

Figure 3




*Sketches of some pathologies present in the structure. A: Corrosion in web transverse beam near of bearing. On the right the same process of corrosion, but in web of lower cord profile of main truss. In some situations this pathology even pierced the web plate. B: Corrosion in flanges of profiles, both of the transverse beams and of the beams. C: View from the lower flange, where, in some cases, much of the flange section had been corroded. D: View of the top flange of profile, where corrosion, in most cases, was only superficial.*

reinforcement in parts where the resistance values found were out of standard or did not meet the needs in front of the efforts generated by the new equipment.

As it was already known by all those involved in the recovery, there was something wrong with the structure, since it had visible deformations. Then it became imperative to stop all activities, with the removal of equipment and cleaning of all parts of trusses, so that the activities were carried out safely.

After cleaning the structures, the pathologies, as shown in Fig. 3 were treated as follows:

A. Manual cleaning with steel brush, with total removal of oxides. Painting of affected parts with corrosion inhibitor. Welding of two plates in an area larger than the affected area, thus ensuring the integrity of web. In the case of connections, these were redone, using A490N screw, with two washers.
B. For the case shown in letter C, chose to cut the corroded part and weld new plate. For letter D in the majority of cases — surface corrosion — a manual brush was cleaned with a steel brush, with total removal of the oxide and painting of the affected parts with corrosion inhibitor and finish paint.

With the structure, at least theoretically, in its original condition, the structural analysis of the same was carried out with the placement of the new loads, aiming at the possible points where the structural reinforcement could be necessary. Since the equipment has a mobile load, the most requested parts could be at any point, and a more careful analysis of the system is necessary. The reinforcement of the structure was carried out only in the main structure (vertical trusses) because the originally sized locking trusses were well above the required resistance.

The connecting plates were retained, since the parts (diagonals and vertical) mostly work under compression, where the failure mode is buckling, without compromising the connection. Even so, the A325X screws (with thread in the cutting plane) were changed to screw A490 (with thread outside the cutting plane). Where there was increased effort, the angles were doubled, obtaining also the double shear of screw, which does not require verification. Due to their thickness, the connecting plates did not need to be altered.

The main truss chords were only subjected to the traction and compression, and to contemplate the proposed load increase it was enough to increase the area of the section of the same ones that the problem would be solved.

After elaboration of reinforcement projects, the structure was deformed, being 3 $^{3}/_{4}$ inches (95 mm), corresponding to L/379, being below the normative limit (L/300 = 120 mm).

Fig. 4 shows the sketches of the solutions adopted to reinforce the structure.

## Conclusion

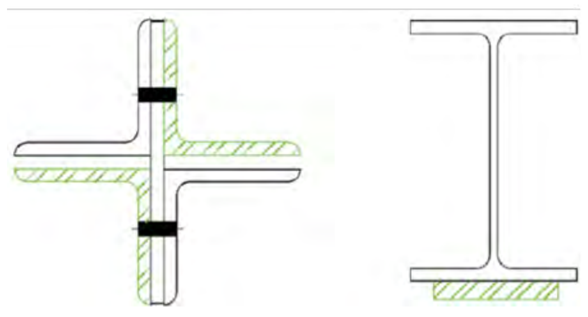
The longevity of a structure in a corrosive environment depends on the observation of all the facts that may occur during its existence. It is necessary for the project to facilitate maintenance and if a structural improvement is required, it can be successfully completed. And, day after day, structural behavior must be observed.

Finally, to obtain a reliable structural system (small or large), it is very important to observe and discuss all possibilities of use and of retrofit.

## Summary

In the iron and steel industry, the possibilities for structural problems are very high. In this way, the design of metal structures must always observe the possibility of corrosion, either by the environmental agents or by the type of product handled. A good structural design contemplates the good performance

Figure 4




*Sketch of the reinforcement executed on the main trusses (in green). Placement of more angles in some verticals and some diagonals. With the doubling of angles, not only the area increase but also the torsional stiffness (a). Welded plate placement at lower flange, for area increase (for upper chord, the placement was given by top flange) (b). For the cases of compression the placement of symmetrical plates is better, but, due to interferences with the connections, the form shown here was the only one possible.*

of the structure, with guarantee of durability and also the possibility of improvements and maintenance.

## Acknowledgments

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## References

1. NBR 8800 – "Design and Construction of Steel Structures for Buildings" (in Portuguese), Rio de Janeiro, Brazil, 1986.
2. NBR 6123 – "Loads Due to Wind in Buildings" (in Portuguese), Rio de Janeiro, Brazil, 1988.
3. *American Institute of Steel Construction Manual,* 13th edition, Chicago, Ill., 2010.
4. ASTM A36 – "Standard Specification for Carbon Structural Steel," West Conshohocken, Pa., USA.
5. ASTM A325 – "Specification for High-Strength Screws for Structural Steel Joints," West Conshohocken, Pa., USA.
6. ASTM A490 – "Standard Specification for Structural Screws, Alloy Steel, Heat Treated, 150 ksi," West Conshohocken, Pa., USA.
7. Araújo, E., "Lecture Notes of the Master Course in Metal Structure" (in Portuguese), EMMOP/UFOP, Ouro Preto, Brazil, 1999.
8. Bellei, I. et al., "Multi-Story Steel Buildings: Design and Calculation" (in Portuguese), 14th edition, Editora Pini, São Paulo, Brazil, 2004.
9. Bellei, I., "Industrial Steel Buildings: Design and Calculation" (in Portuguese), 4th edition, Editora Pini, São Paulo, Brazil, 2003.
10. SIDERBRÁS: Siderurgia Brasileira S.A., "Brazilian Manual for Calculating Metallic Structures" (in Portuguese), Brasília, Brazil.
11. Software MCalc3D, Version 5.0 – Stabile, Porto Alegre, Brazil. ✦

This paper was presented at AISTech 2019 — The Iron & Steel Technology Conference and Exposition, Pittsburgh, Pa., USA, and published in the Conference Proceedings.

## Did You Know?

### Nucor, AK Steel Receive Supplier Honors

AK Steel and Nucor have been recognized as General Motors (GM) Suppliers of the Year, a honor presented to the automaker's vendors that distinguish themselves by providing innovative technologies and high-quality parts, materials and services.

"Our suppliers play a key role in delivering the products, services and experiences our customers deserve — and these award-winning suppliers went above and beyond our expectations," said GM vice president Shilpan Amin, who oversees the company's global purchasing and supply chain.

It's the second year in a row Nucor has received the recognition, and it's the only mini-mill operator on the automaker's list of recognized suppliers.

"We value the partnership we've built with GM, working together to meet their needs for automotive steel products. We look forward to continuing to grow as partners for years to come," said Nucor president and chief executive Leon Topalian.

Lourenco Goncalves, chairman and chief executive of AK Steel parent Cleveland-Cliffs Inc., said the award recognizes the technical and commercial support it provides to GM.

"More than anything, we value our collaborative relationship with GM," Goncalves said. "We are committed to continuing to work with GM to design steel solutions for their existing and new vehicles. GM's commitment with the future of the automotive industry is also our commitment."

The Supplier of the Year award winners are chosen by a global team of GM purchasing, engineering, quality, manufacturing and logistics executives. Winners are selected based on performance criteria in product purchasing, global purchasing and manufacturing services, customer care and aftersales, and logistics.

# Copper Stave Bending: Challenges, Management and Solutions


## Authors

Robert Horwood
senior mechanical engineer,
Primetals Technologies Ltd.,
Stockton-on-Tees, U.K.
robert.horwood@primetals.com

Robert Mawer
senior technologist,
Primetals Technologies Ltd.,
Stockton-on-Tees, U.K.
robert.mawer@primetals.com

Richard Harvey
technical manager,
Primetals Technologies Ltd.,
Stockton-on-Tees, U.K.
harvey.richard@primetals.com

David Osborne
technology director,
Primetals Technologies Ltd.,
Stockton-on-Tees, U.K.
dave.osborne@primetals.com



Copper staves have now been used in blast furnaces for 40 years, and Primetals Technologies has had great success with this technology — in terms of the stave designs, the profiling of the blast furnace, and the operational strategies that can be used to support a 20-year campaign. However, a number of non-Primetals Technologies furnaces have suffered from challenges when implementing copper staves. This paper will reference some of the problems in bending and wear that customers have encountered, along with the solutions Primetals Technologies currently offers.


An important factor in extending the life of the blast furnace operating campaign has been the quality and durability of the furnace shell protection system. As demands on productivity have increased, so have the operating pressures of the blast furnace. This has meant thicker furnace shells, which have required greater reliability of the protective cooling systems in order to ensure that the structural integrity of the blast furnace could be maintained.

Copper plate coolers became the predominant cooling systems of the mid-1900s but their limited campaign life and requirement for gunnite repair led to the development of stave cooling. Initially the stave solution was manufactured from cast iron — this was developed in Russia with further enhancements made in Japan. The stave solution provided more consistent campaigns, albeit there were still improvements to be made as the cast iron stave lifetime in the high heat zones of the furnace was around 10–12 years.

Copper staves were introduced to enhance the heat removal capabilities in these areas and thus improve stave lifetimes. The use of copper in these areas meant an increase in the ability of the cooling system to handle higher heat loads. In many plants, copper staves have proven to be very reliable in protecting the structural integrity of the blast furnace shell.

The current situation is that refractory quality and cooling intensity for plate-cooled furnaces have increased such that long campaign lives can be achieved with both plate-cooled furnaces and copper stave-cooled furnaces, but there are enhancements in stave design that have been engineered to overcome two of the issues seen on some copper stave-cooled furnaces. These two issues are stave wear and stave bending. This paper will focus on the issues copper staves have faced through stave bending: why the problem occurs, how it can be managed through a campaign and how to prevent it from happening altogether for a trouble-free campaign life.

## Discussion

**What Is Stave Bending?** — When trial copper staves were first installed into the blast furnace, the focus was very much on the hot face of the stave and how it was performing. Success in the freezing of a self-protecting accretion layer was observed and confidence that using copper in the high heat zones to achieve a long lifetime was realized.

The trial periods provided no concerns with stave bending and failures of the welded connection of stave pipe to body were not seen.

Copper staves gradually became a more popular solution during the late 1990s. With more installations and increased operational time, a number of furnaces reported problems with water leaks into the furnace from the welded connection of the pipe to the body.

Staves are exposed to high temperatures within the blast furnace. During operation, an accretion layer similar to that shown in Fig. 1 is frozen to the hot face of the stave and protects the stave during its time in the blast furnace. From time to time, the accretion layer falls off, and for a short duration the stave temperature increases while a new accretion layer forms. This cyclic situation can see the hot face of the stave fluctuate from 70°C to 200°C. These changes in temperature along with the stave's inherent hot and cold face cause the stave to expand and move in varying ways, which can impart stresses to certain parts of the body.

The fluctuations of stave body temperatures cause the stave to expand and move during operation. These movements cause the stave to bend in different manners depending on how the stave is fixed to the shell. Theoretically, it would be expected for the stave to "belly" into the furnace as the hot face should expand more than the cold face; in reality, the movements are the opposite due to the stave fixings and the grout, which fills the void between the shell and the stave.

As the stave goes through the temperature cycles explained previously, gaps are created behind the stave, especially at the corners. These gaps allow a path for both burden material and dust to get behind. The material fills the gaps and prevents the stave from returning to its original position when it cools. Over time this can have two effects:

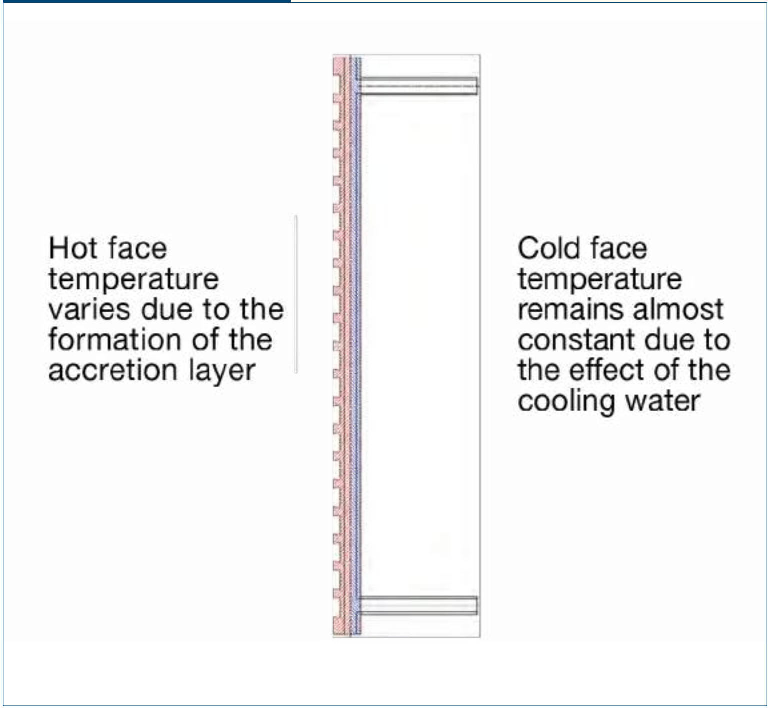
- The bending gets worse and the stave "ratchets" further from the shell, inducing stresses into the pipe-to-body weld until failure occurs.
- Dust fills the compensator bellows and locks them in place, preventing any movements and causing stresses to once again go to the welded connection until failure.

Managing Stave Bending — Stave design is the most important factor in preventing stave bending. Once

Figure 1

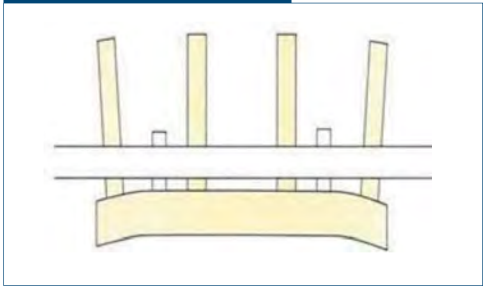
*Accretion buildup on an early copper stave.*

Figure 2




*Stave hot and cold face.*

Figure 3



*Stave bending.*

the staves are installed it becomes very difficult to prevent the problem from arising.

Correct installation procedures are also imperative to ensure that any allowable movements built into the design are accounted for. It is good practice to ensure clearances around the cooling pipes and the shell holes, ensuring that the backfill grout that fills the void between the shell and stave does not surround the pipe and fix it in position. It is important that the compensators are installed over the cooling pipes concentrically and the dimensions between the copper pipe and compensator at four points (3, 6, 9 and 12 o'clock) are recorded. These dimensions can be retaken periodically and any movements highlighted, which can help with the estimation of a problem occurring.

Failure of the welded connection is very challenging to repair. Depending on the campaign life, an operator may make the decision to isolate/bypass that cooling channel; however, if the staves have only recently been installed, then repairs are often required. Repairing is no easy task, and shutdowns and correct access are essential to undertake a good repair. This can often involve cutting sections of furnace shell away and then undertaking the repair work in tight situations under significant time pressures.

**Stave Design Features —** The copper stave has a number of design features. Like with all products, there are good designs and there are not-so-good designs. The understanding of copper staves expansion is imperative in producing a good copper stave design. Fig. 5 shows the optimum stave design to provide a trouble-free campaign.

**Fixed Pin:** The fixed pin is a common feature on the copper stave. Initially, this pin was welded to the inside of the furnace shell and then the stave was hung onto it. This design proved problematic for installation but it also provided no stability to the stave during operation. The modern method has the pin screwed into the stave body and then welded to the outside of the furnace shell with a large washer.

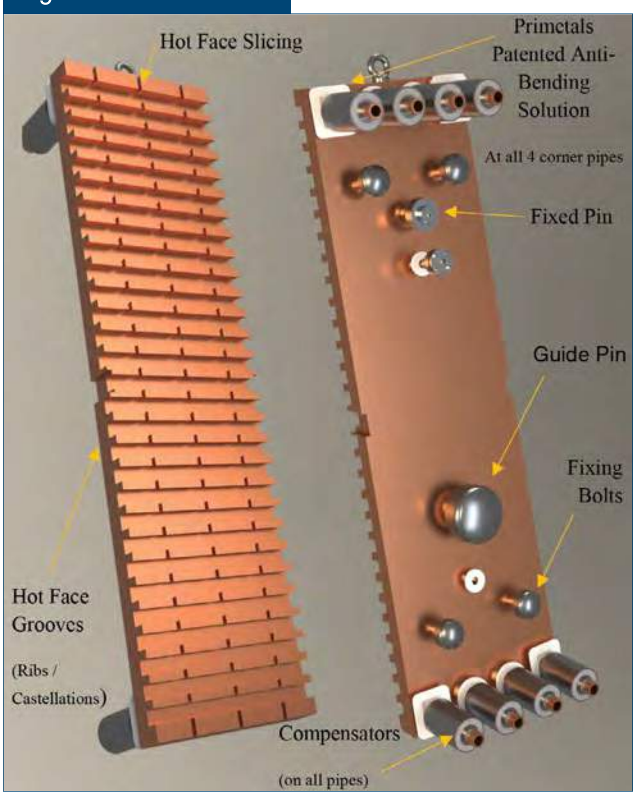
The fixed pin should be the only fully fixed point of the stave from where all stave expansion originates. This knowledge allows one to understand how to prevent stave bending.

**Compensators:** In the very early days of copper staves, there was little to no allowance for stave expansion. The copper pipes were grouted in place and essentially fully fixed. The understanding that was gained during the early issues of the copper stave led to the inclusion of compensators on each stave pipe. The compensator is an expansion joint that creates a gas seal to the furnace while allowing for ~15 mm movement.

Figure 4

*Repair method used on a failed copper stave pipe.*

Figure 5

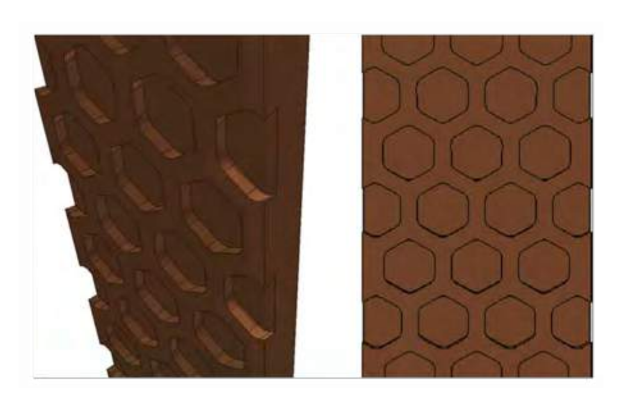



*Stave design features.*

Figure 6

*Diagonal and vertical slicing of stave hot face.*

Figure 7

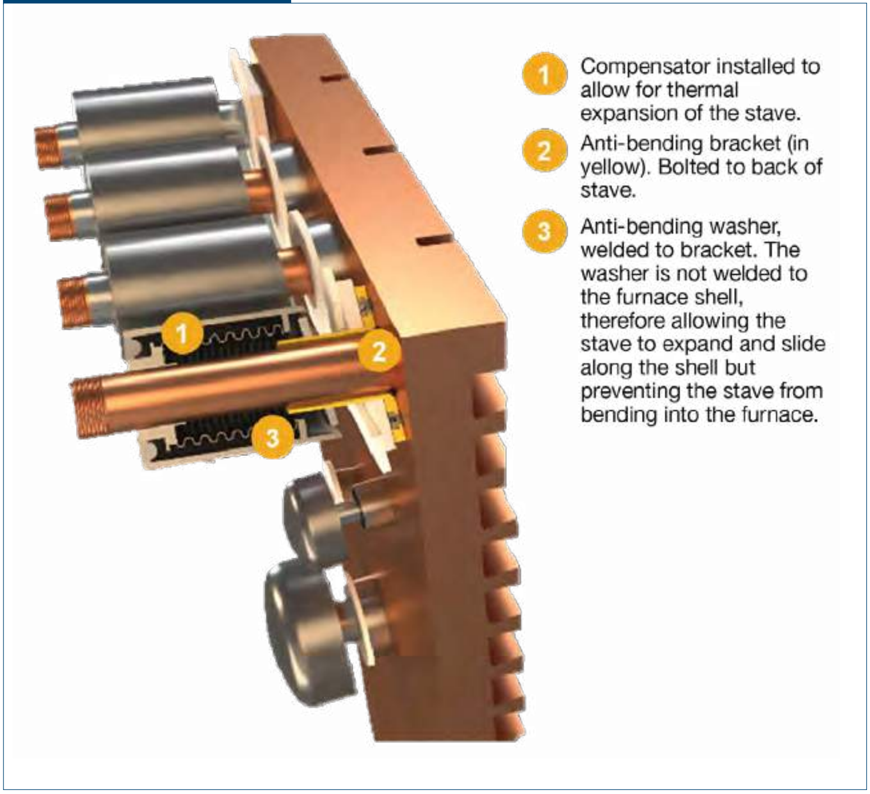


*Next-generation stave design.*

Fixing Bolts: The fixing bolts when first included were an installation aid to pull the stave into position against the furnace shell. In recent years, as stave bending became an issue, it was seen that the bolts provided additional support to the stave during operation. It has become good practice to locate the bolts close to the corners of the stave to provide support during operation.

Guide Pin: On successfully performing staves that have not experienced bending, a second pin has often been implemented. This pin is similar to the fixed pin but is not welded to the furnace shell. For this reason it is called the guide pin and it allows the stave to expand along the shell but prevents the stave from bending into the furnace and therefore reduces the bending impact.

Figure 8




*Patented anti-bending solution successfully installed on multiple furnaces.*

Hot Face Design — The design of the hot face of the stave has a significant impact on how the stave moves and expands. The traditional stave design contains a series of dovetail grooves down the hot face to capture material and promote the accretion buildup. Vertical or diagonal slots are now common features that are machined into the copper stave. These slots aim to relieve stresses within the hot face of the stave and reduce the bending effect. While initially these features proved to be successful, it has since become apparent that while they may show some improvements, many staves with these features have still failed through bending.

The traditional dovetail groove design was initially adopted from the cast iron stave and was suitable for the copper stave since it was a simple shape to machine. The arrangement of these horizontal dovetailed grooves provide stiffness to the stave in one direction only and it can therefore be no surprise that the stave "bananas" in the way that it does. Manufacturing techniques have changed significantly since the first copper stave, which has allowed designers more flexibility in hot face layouts. Modern-day CNC machining gives the designer greater flexibility in their designs, which has allowed for a variety of options for the stave's hot face. New shapes have been reviewed and in particular a honeycomb design has shown benefits due to its pattern, which promotes a homogeneous stiffness and cooling that can significantly reduce the impact of stave bending.

A trial with this novel hot face design has been installed alongside comparison staves of traditional design. Data from these staves, which have been in operation for over 6 months now, is very positive. In addition, slide-in inserts have been developed that offer increased wear resistance to operators who prefer to maintain the traditional hot face design.

**Anti-Bending Solution** — A patented solution that has been developed and proven on a number of furnaces is shown in Fig. 8. This solution allows the stave to expand and move under its thermal load but controls the stave's movements and thus prevents stave bending. The solution is located on each corner pipe of the stave (typically four locations). The stave is allowed to grow and slide along the furnace shell but it is prevented from bending into the furnace, which causes the stresses to be imparted onto the weld. This is the only proven solution currently available that fixes the problem of stave bending at the source.

## Conclusions

Water leaks into the furnace, no matter where from, are a serious issue for the blast furnace operator. Copper staves have encountered some serious issues with stave bending that can ultimately cause water leaks into the furnace. The result of this often means the isolation of the damaged cooling channel, which reduces the stave's lifetime significantly and can cause hot spots on the furnace shell. Stave bending is directly attributed to temperature fluctuations of the stave. These fluctuations cannot be prevented as they are part of the operation of staves whereby the protective accretion layer is built up, falls off and builds up again. This means that the mechanical design of the copper stave is critical to ensuring that a trouble-free operation can be maintained. However, a successful operation and campaign can be obtained given the correct stave design. The following points should be considered to guarantee a trouble-free campaign:

- Understand the expansion philosophy.
- Include a fixed and guide pin in the design.
- Include the anti-bending solution.
- Consider different hot face designs — in particular that of a honeycomb pattern.

It's important to remember that it is impossible to stop thermal expansion, but it is possible to control that expansion. Using the correct features and design as outlined above demonstrates that a successful campaign can be accomplished. ✦

AISTech This paper was presented at AISTech 2019 — The Iron & Steel Technology Conference and Exposition, Pittsburgh, Pa., USA, and published in the Conference Proceedings.

### Did You Know?

**GM Awards ArcelorMittal Plants With Supplier Excellence Award**

ArcelorMittal was recognized with the 2019 Supplier Quality Excellence Award by General Motors (GM). Three ArcelorMittal facilities received the prestigious honors: ArcelorMittal USA's Indiana Harbor and I/N Tek and Kote facilities, AM/NS Calvert LLC and ArcelorMittal Dofasco G.P. This marked the third year in a row that AM/NS Calvert has been recognized. It was also a second consecutive award for Indiana Harbor, and I/N Tek and I/N Kote.

"We are very proud of our partnership with General Motors across our sites, and this recognition is a testament to our employees' dedication to superior quality and service," said John Cardwell, ArcelorMittal's director of automotive sales.

General Motors utilizes thousands of suppliers around the world, but only a small fraction of those receive the Supplier Quality Excellence Award. To receive the award, steel facilities must meet General Motor's most stringent quality requirements. Such quality metrics include: low overall quality issues and rejection rates; maintenance of quality certifications; and no plant disruptions or major shipping issues.

"General Motors' mission is to design, build and sell the world's best vehicles with the highest levels of quality and safety on the road," said Richard Demuynck, executive director of GM's global supplier quality and development, wrote in announcing this year's awards.

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**W**e look forward to the opportunity to be of service for your needs. Thank you for your consideration of Wise Machine and Grayfin Manufacturing.

Best Regards


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President
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# 28TH CRANE SYMPOSIUM

## 13–15 JUNE 2021 | PITTSBURGH, PA., USA

## Call for Presentations

The symposium will deliver practical information and experiences from crane maintenance personnel, crane manufacturers, equipment manufacturers and engineering consultants who strive to make electric overhead traveling (EOT) cranes and their runways the safest, most reliable, durable machinery and equipment in the industry. This two-day program will include presentations focused on safe work practices and ergonomics; electrical, mechanical and structural maintenance techniques; crane inspection technologies; and best practices in EOT crane modernizations. As part of the Crane Symposium program, the Charlie Totten Crane Innovator Award winner will be announced, recognizing the individual who has brought forth the latest in technology, or increased efficiencies in operational and maintenance practices for the continuous improvement of heavy industrial cranes.

To encourage candid discussion and to accommodate the most recent findings, written manuscripts are not required. Authors will need to submit a PowerPoint presentation that will be made available to attendees.

### Deadline Dates

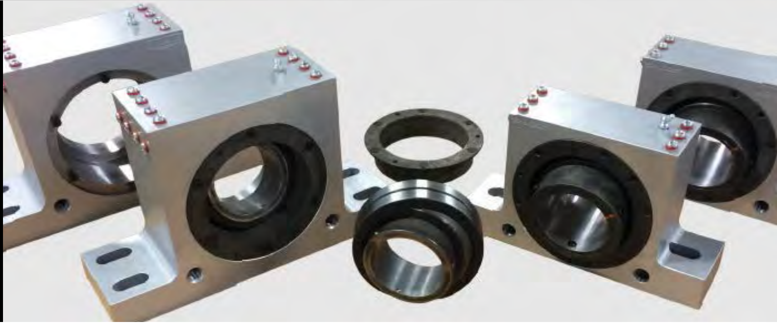
Abstract Submission: 6 November 2020
Abstract Acceptance Notification: 4 December 2020
Presentation Submission Deadline: 17 May 2021

**Visit AIST.org for more information or to submit your abstract.**

### Organizing Committee

AIST Cranes
Technology Committee


Titan Bearings Succeed
Where Other Bearings
Continue to Fail



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# *Call for Papers and Presentations*

AISTech 2021

**Abstracts due by 30 September 2020**

The Association for Iron & Steel Technology (AIST) is an international technical association representing iron and steel producers, their allied suppliers and related academia. AIST is recognized as a global leader in networking, education and sustainability programs for advancing iron and steel technology.

AISTech 2021 — The Iron & Steel Technology Conference and Exposition is scheduled for 3–6 May 2021 at the Music City Center, Nashville, Tenn., USA. Abstracts for this major international conference are being sought now for manuscripts to be presented at the event and published in the proceedings.

AISTech 2021 will feature technologies from all over the world to help steel producers compete more effectively in today's global market. If you are involved in the steel industry, you can't afford to miss this event. Whether you present, attend or exhibit, take advantage of this opportunity to discover ways to make your job easier and improve your productivity.

## International Exposure

All papers presented at AISTech 2021 are considered for publication in *Iron & Steel Technology*, AIST's monthly technical journal, with distribution to more than 16,000 recipients worldwide. All papers presented are eligible for inclusion in the Conference Proceedings.

## Participant Opportunities: Call for Papers and Presentations

The AISTech Iron & Steel Technology Conference promotes the transfer of iron and steel technology by providing an international forum for authors to share ideas, experiences and knowledge of the industry. We invite you to submit your abstracts for consideration. AIST offers two opportunities to participate in AISTech 2021's Technology Conference. Choose the option that best suits your objectives and available resources.

## Option 1: Technical Paper

Papers presented during this technology conference are subsequently considered for publication in *Iron & Steel Technology*. Selection of papers for publication is based on the following factors: recommendations from sponsoring Technology Committee members; technical content, quality and current interest; quality of figures (should not require extensive reworking); and peer-review evaluations. Accepted papers may be published in the AISTech 2021 Conference Proceedings and are eligible for AIST Awards and Recognition, including the Hunt-Kelly Outstanding Paper Award, which features a US$5,000, US$2,500 and US$1,000 prize for the three highest-rated papers.

Technical papers selected for publication will receive a Digital Object Identifier (DOI), a unique alphanumeric identifier applied to a specific piece of intellectual property. DOIs are key components of reference-linking systems and help increase exposure for AISTech authors and papers.

## Option 2: Presentation Only

Abstracts for Presentation Only are also being accepted for consideration.

*PLEASE NOTE: Presentations without a corresponding paper will not be published in the AISTech 2021 Conference Proceedings, will not be eligible for publication in* Iron & Steel Technology*, and will not be eligible for any AIST Awards or Recognition.*

## Program Development and Topics

AIST Technology Conference programs are developed by Technology Committee members representing iron and steel producers, their allied suppliers and related academia. Committees focus on ironmaking, steelmaking, finishing processes, and various engineering and equipment technologies. Sessions currently being developed focus on the following topics:

- Safety & Health
- Environmental
- Cokemaking
- Ironmaking
- Direct Reduced Iron
- Electric Steelmaking
- Oxygen Steelmaking
- Specialty Alloy & Foundry
- Ladle & Secondary Refining
- Continuous Casting
- Hot Sheet Rolling
- Cold Sheet Rolling
- Galvanizing
- Tinplate Mill Products
- Plate Rolling
- Long Products
- Pipe & Tube
- Rolls
- Metallurgy — Steelmaking & Casting
- Metallurgy — Processing, Products & Applications
- Energy & Utilities
- Electrical Applications
- Digitalization Applications
- Project & Construction Management
- Maintenance & Reliability
- Lubrication & Hydraulics
- Refractory Systems
- Material Handling
- Cranes
- Transportation & Logistics

## Student Papers and Contests

Graduate and undergraduate students may present findings on completed research, research in progress, university projects or co-op experiences as part of the technical program at AISTech.

AIST also holds the Undergraduate Student Project Presentation Contest and the Graduate Student Poster Contest at AISTech to showcase student projects and research while offering cash prizes. For more information, visit AISTech.org.

## Abstract Submittal Deadline

*30 September 2020*

Whether you are preparing a technical paper or a presentation, the first step is to submit an abstract for the Technology Committees to review. The subject matter should be of current interest to those in the iron and steel industry and should present new developments, methods or applications. Please limit your abstract to 100 words and include the following information:

- Paper Title
- Author's Name
- Title
- Company Affiliation
- Complete Mailing Address
- Phone
- Email
- Co-Author Name(s)
- Title(s)
- Company Affiliation(s)

Submit abstracts online at AISTech.org.

## Letter of Invitation to Selected Authors

*18 November 2020*

If your abstract is selected, AIST will send you a formal letter of invitation. This letter contains necessary information, including registration requirements for accepted papers. The guidelines to assist with the preparation of the final paper will be posted on the Hubb Speaker Portal. If your abstract is not initially selected, we will retain the abstract in case of cancellations in the program.

## Final Author Acceptance Response Due to AIST

*2 January 2021*

To verify your acceptance and commitment to present, we require a  response to our letter of invitation.

## Technical Papers Due to AIST

*18 February 2021*

Technical papers must be submitted to AIST by 15 February 2021 to be considered for inclusion in the Conference Proceedings, which are made available to conference registrants. Papers presented during AISTech are subsequently considered for publication in *Iron & Steel Technology*. A signed and completed copyright form must also be submitted with the original manuscript. The Author Guide, which provides guidelines for preparing a technical paper for AISTech, as well as a paper template, is on the AIST Speaker Portal.

## Presenter Registration Deadline

*2 March 2021*

This is the final date for presenters to register for the Full Conference in order to present and to have their technical papers published in the Conference Proceedings.

## Presentation Draft Due to AIST

*18 March 2021*

A total of 30 minutes is allotted for each presentation. It is suggested that the formal presentation be approximately 20 minutes long, allowing 10 minutes for questions and discussion. When preparing your presentation, please use one of the PowerPoint presentation templates available on the AIST Speaker Portal.

## Questions?

Please contact Anna Voss at +1.724.814.3097 or avoss@aist.org.

### Commercialism Guideline

Papers and presentations delivered at AIST-sponsored forums are intended to be technical in nature, with solutions supported by verifiable data. Commercially motivated commentary or endorsement of specific brands or companies is not acceptable. Each paper/presentation will be peer reviewed by forum organizers to ensure compliance with this policy. If the paper/presentation is deemed to be in violation, the author/presenter will be notified by the forum organizer(s) and given the opportunity to revise the content or to withdraw the paper/presentation. To preserve and protect the interests of AIST, forum organizers will have the authority and the responsibility to stop any paper/presentation they determine to be in violation of this policy.

### Plagiarism Policy

The Association for Iron & Steel Technology (AIST) seeks to maintain the highest standards in all activities to serve the steel industry. AIST expects its members, authors and presenters to adhere to these standards within any AIST function or forum. This includes the development, submittal, and presentation of written or electronic material for publication. Plagiarism within submitted work will not be tolerated.

### AIST Anti-Harassment Policy

AIST is dedicated to providing harassment-free events for everyone, regardless of age, race, religion, disability, gender, gender identity or sexual orientation. We do not tolerate harassment in any form of anyone attending an AIST event.

Harassing behaviors include: offensive verbal comments related to age, race, religion, disability, gender, gender identity or sexual orientation; the use or display of sexual images, activities or commentary in public spaces; deliberate intimidation; stalking or following; harassing photography or recording; sustained disruption of events; or inappropriate physical contact.

Participants asked to stop any harassing behavior are expected to comply immediately. Participants violating this policy may be sanctioned or expelled from the event or the membership at the discretion of the AIST leadership.

**ADVANCE PROGRAM**

REGISTER BEFORE 3 SEPTEMBER 2020 TO SAVE!

Technical Meeting and Exhibition

# MS&T20

#MST20

## MATERIALS SCIENCE & TECHNOLOGY

DAVID L. LAWRENCE CONVENTION CENTER | PITTSBURGH, PENNSYLVANIA, USA

## WHERE MATERIALS INNOVATION HAPPENS

Organizers:

The American Ceramic Society
www.ceramics.org

AIST ASSOCIATION FOR IRON & STEEL TECHNOLOGY

TMS The Minerals, Metals & Materials Society

**MATSCITECH.ORG/MST20**

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Technical Meeting and Exhibition

# MS&T20

MATERIALS SCIENCE & TECHNOLOGY

#MST20

4–8 OCTOBER 2020 | DAVID L. LAWRENCE CONVENTION CENTER | PITTSBURGH, PA., USA

## PLENARY SPEAKERS

Visit the MS&T Plenary Speakers webpage to view the complete abstracts and bios.

**AIST ADOLF MARTENS MEMORIAL STEEL LECTURE**

**Nina Fonstein**
manager (retired), Automotive Product Development Group, Global R&D, ArcelorMittal, USA

**TMS/ASM JOINT DISTINGUISHED LECTURESHIP IN MATERIALS AND SOCIETY**

**Charles H. Ward**
chief, Manufacturing and Industrial Technologies Division, Air Force Research Laboratory, USA

**ACerS EDWARD ORTON JR. MEMORIAL LECTURE**

**Mrityunjay Singh**
chief scientist, Ohio Aerospace Institute, USA

## PROGRAM AT A GLANCE

Materials Science & Technology (MS&T) is where materials innovation happens! Each year, MS&T's long-standing, recognized forum brings together scientists, engineers, students, suppliers, and business leaders to discuss current research and technical applications to shape the future of materials science and technology. The event's unmatched technical program fosters technical innovation at the intersection of materials science, engineering, and application — addressing structure, properties, processing and performance across the materials community.

Join other materials science experts from three leading materials societies to discuss the latest advancements in your field. MS&T20 features the following events:

**AIST STEEL PROPERTIES AND APPLICATIONS**

Technical developments related to ferrous metallurgy and steel manufacturing.

**ACerS 122ND ANNUAL MEETING**

Advancing the industry with the latest research in ceramics and glass.

**TMS FALL MEETING**

Exploring the intersections of development, synthesis and application.

## COVID-19 UPDATE

Your safety and well-being are our top priority! At this time, we are moving forward with MS&T20 as scheduled. The MS&T organizing societies are monitoring news and information related to COVID-19 on an ongoing basis and will follow guidance from the U.S. Centers for Disease Control and Prevention, the World Health Organization, and federal, state, and local governments. If plans should change, we will provide updates through the MS&T20 website and by email to registrants, exhibitors, presenters, and other confirmed participants.

# ADVANCE PROGRAM

REGISTER BEFORE 3 SEPTEMBER 2020 TO SAVE!

The American Ceramic Society www.ceramics.org Annual Meeting | AIST Association for Iron & Steel Technology Steel Properties & Applications | TMS Fall Meeting

## LECTURES AND AWARDS

**ACerS/EPDC ARTHUR L. FRIEDBERG CERAMIC ENGINEERING TUTORIAL AND LECTURE**

Monday, 5 October | 9–10 a.m.

John R. Hellmann, The Pennsylvania State University, USA

**ACerS RICHARD M. FULRATH AWARD SESSION**

Monday, 5 October | 2–4:40 p.m.

Shashank Priya, The Pennsylvania State University, USA

Tomoaki Yamada, Nagoya University, Japan

Takeshi Kobayashi, National Institute of Advanced Industrial Science and Technology, Japan

Hiroshi Sato, TDK Electronics GmbH & Co. OG, Japan

Edward P. Gorzkowski III, U.S. Naval Research Lab, USA

**ACerS FRONTIERS OF SCIENCE AND SOCIETY — RUSTUM ROY LECTURE**

Tuesday, 6 October | 1–2 p.m.

James Adair, The Pennsylvania State University, USA

**ACerS GOMD ALFRED R. COOPER AWARD SESSION COOPER DISTINGUISHED LECTURE**

Tuesday, 6 October | 2–4:30 p.m.

John Kieffer, University of Michigan, USA

**ACerS GOMD ALFRED R. COOPER YOUNG SCHOLAR AWARD PRESENTATION**

Winners will be announced after selection by the Cooper Award Committee.

**ACerS BASIC SCIENCE DIVISION ROBERT B. SOSMAN LECTURE**

Wednesday, 7 October | 1–2 p.m.

Wayne Kaplan, Technion – Israel Institute of Technology, Israel

## TECHNICAL PROGRAM

Visit the MS&T Technical Program webpage to view the complete technical program and topics.

- ADDITIVE MANUFACTURING
- ARTIFICIAL INTELLIGENCE
- BIOMATERIALS
- CERAMIC AND GLASS MATERIALS
- ELECTRONIC AND MAGNETIC MATERIALS
- ENERGY
- FUNDAMENTALS AND CHARACTERIZATION
- IRON AND STEEL (FERROUS ALLOYS)
- MATERIALS-ENVIRONMENT INTERACTIONS
- MODELING
- NANOMATERIALS
- PROCESSING AND MANUFACTURING
- SPECIAL TOPICS

**MATSCITECH.ORG/MST20**

Technical Meeting and Exhibition

# MS&T20

MATERIALS SCIENCE & TECHNOLOGY

#MST20

4–8 OCTOBER 2020 | DAVID L. LAWRENCE CONVENTION CENTER | PITTSBURGH, PA., USA

## SPECIAL EVENTS

Visit the MS&T Special Events webpage to see all special events, including dates and times.

**MS&T WOMEN IN MATERIALS SCIENCE RECEPTION**

Sunday, 4 October | 5–6 p.m.

**ACerS 122ND ANNUAL MEMBERSHIP MEETING**

Monday, 5 October | 1–2 p.m.

**MS&T PARTNERS' WELCOME RECEPTION**

Monday, 5 October | 5–6 p.m.

**AIST STEEL TO STUDENTS RECEPTION**

Monday, 5 October | 6–8 p.m.

**ACerS ANNUAL HONOR AND AWARDS BANQUET**

Monday, 5 October | 7:30–10 p.m.

**ACerS BASIC SCIENCE DIVISION CERAMOGRAPHIC**

Exhibit and Competition
5–8 October | various hours

General Poster Session With Presenters
Tuesday, 6 October | various hours

**TMS YOUNG PROFESSIONAL TUTORIAL LUNCHEON AND LECTURE**

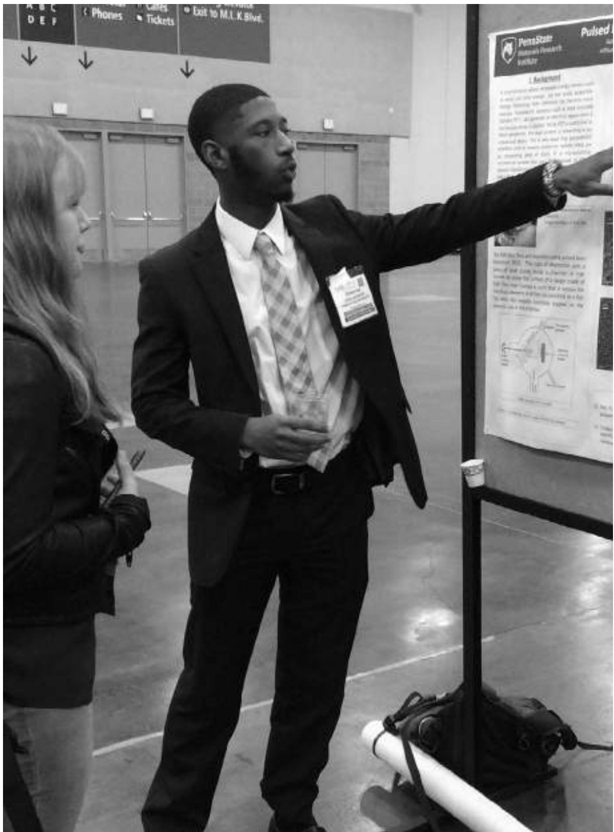
Tuesday, 6 October | Noon–12:45 p.m.

## LATE NEWS POSTER SESSION

Want to share your latest research at MS&T? Submit an abstract for the Late News Poster Session! Topics can include any of those listed. Submit abstracts at programmaster.org/MST20.

Questions? Contact programming@programmaster.org.

**Abstracts due: 31 AUGUST 2020**



# ADVANCE PROGRAM

REGISTER BEFORE 3 SEPTEMBER 2020 TO SAVE!

The American Ceramic Society www.ceramics.org Annual Meeting | AIST Association for Iron & Steel Technology Steel Properties & Applications | TMS Fall Meeting

## SHORT COURSES

View the MS&T Short Course webpage for dates and times.

**SINTERING OF CERAMICS**

Saturday, 3 October | 9 a.m.–4:30 p.m.

Sunday, 4 October | 9 a.m.–2:30 p.m.

Instructor: Ricardo Castro, University of California – Davis

## STUDENT ACTIVITIES

Visit the MS&T Student Activities webpage to see complete descriptions of all student events, including details for applying for Material Advantage chapter travel grants and individual travel grants.

- UNDERGRADUATE STUDENT POSTER CONTEST
- GRADUATE STUDENT POSTER CONTEST
- MATERIAL ADVANTAGE CHAPTER OFFICER WORKSHOP
- UNDERGRADUATE STUDENT SPEAKING CONTEST
- STUDENT NETWORKING HAPPY HOUR
- ACerS STUDENT TOUR
- AIST STUDENT PLANT TOUR OF ATI'S HOT ROLLING AND PROCESSING FACILITY
- ACerS PCSA HUMANITARIAN ENGINEERING SYMPOSIUM
- CERAMIC MUG DROP CONTEST
- CERAMIC DISC GOLF CONTEST
- CAREER FAIR
- STUDENT AWARDS CEREMONY

## HOTELS

Visit the Housing webpage for detailed information on hotels and visa information.

**WESTIN PITTSBURGH**

ACerS Headquarters Hotel
US$229 plus tax/night single or double


**OMNI WILLIAM PENN HOTEL**

AIST and TMS Headquarters Hotel
US$219 plus tax/night single or double

**COURTYARD BY MARRIOTT PITTSBURGH**
US$209 plus tax/night single or double

**DRURY PLAZA HOTEL PITTSBURGH DOWNTOWN**
US$179 plus tax/night single or double

**HAMPTON INN AND SUITES PITTSBURGH**
US$199 plus tax/night single or double


# EXHIBITION

Meet and network with reps from companies specializing in materials science and engineering-related products and services. Attractions on the show floor include poster sessions, mug drop competition, ceramic disc golf competition, career fair and an exhibitor networking reception.

**EXHIBIT SHOW HOURS:**

**Tuesday, 6 October**
10 a.m.–6 p.m.
Exhibitor networking reception: 4–6 p.m.

**Wednesday, 7 October**
9:30 a.m.–2 p.m.

Visit the Exhibits webpage for rates on booth rental, sponsorship, advertising rates, plus more details on marketing your company at MS&T20.

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# REGISTRATION

Visit the Registration webpage to see what your registration includes.

| Rates | On or before 3 September | After 3 September |
|---|---|---|
| Member | US$660 | US$810 |
| Non-Member | US$810 | US$960 |
| Presenter (Speaker, Organizer, Session Chair) Member | US$610 | US$760 |
| Presenter (Speaker, Organizer, Session Chair) Non-Member[1] | US$760 | US$910 |
| Undergraduate Student Member[2] | US$25 | US$75 |
| Undergraduate Student Non-Member [2,3] | US$25 | US$75 |
| Graduate Student Presenter, Member[2] | US$110 | US$160 |
| Graduate Student Member[2] | US$135 | US$185 |
| Graduate Student Presenter, Non-Member [2,3] | US$140 | US$190 |
| Graduate Student Non-Member[2,3] | US$165 | US$215 |
| One-Day Member | US$535 | US$685 |
| One-Day Non-Member | US$685 | US$835 |
| Exhibit Only | US$25 | US$25 |
| ACerS Awards Banquet | US$100 | US$100 |
| TMS Young Professional Tutorial Lecture | US$40 | US$40 |

[1]Non-member fee includes a complimentary one-year membership to registrant's choice of one or more organizations: ACerS, AIST, and/or TMS.

[2]To qualify for the student rate, registrant must provide student ID. Please be prepared to present a current school ID when picking up your badge on-site.

[3]Non-member student fee includes a complimentary one-year membership in Material Advantage (the ACerS/AIST/ASM/TMS joint student program).


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TWO EVENTS, ONE LOCATION

# 2020 8–10 November LEADERSHIP CONFERENCE

Omni Rancho Las Palmas Resort & Spa
Rancho Mirage, Calif., USA

in conjunction with **AIST's WESTERN CONFERENCE**

TAKE ADVANTAGE OF THIS OPPORTUNITY TO EXPAND YOUR VISIBILITY AND INCREASE YOUR EFFICIENCY!

**Strengthen your network at the following events:**

## AIST LEADERSHIP CONFERENCE

This invitation-only event is open to all Member Chapter officers, Technology Committee officers and AIST's Board of Directors. The conference objective is to enhance the value of participation in AIST activities and provide resources to help attendees grow as leaders in the association and the steel industry.

## AIST WESTERN CONFERENCE

The AIST Western Conference is hosted by the Southern California and Northern Pacific Member Chapters. With technical presentations, a golf outing, vendor displays, shared meals, breaks and receptions, this event provides attendees with superior networking opportunities and education about new technologies affecting local steel-related businesses and the future of the steel industry.

AIST's Southern California Member Chapter will be hosting their annual dinner dance that will kick off the weekend leading into the AIST Western and Leadership Conferences at the Omni Rancho Las Palmas Resort & Spa, Rancho Mirage, Calif., USA.

Important Information: both events will be held concurrently, and you must register for the specific conference that you plan to attend. All participants will be able to attend common networking opportunities and social functions.

## VENDOR DISPLAY OPPORTUNITIES ARE AVAILABLE!

For more information, please contact Jill Liberto (jliberto@aist.org) or visit AIST.org.

## SPONSORSHIP OPPORTUNITIES

All Sunday–Tuesday sponsors receive the following: inclusion as a conference event contributor in promotional emails and *Iron & Steel Technology (I&ST)* ads, on-site AIST PowerPoint presentations, Leadership Conference electronic binder and websites for the Leadership Conference and Western Conference, and acknowledgment during the opening and closing statements by the Executive Director.

## SUNDAY, 8 NOVEMBER–TUESDAY, 10 NOVEMBER 2020

### Premier Sponsor
~~US$10,000~~ SOLD OUT

TMEIC We drive industry

Recognition as premier sponsor and company logo on all event signage. One, two-page 4-color spread in *I&ST* magazine. One 6-foot table at vendor fair and a foursome in the golf outing. Banner ad and hyperlink in the conference recap email sent to all attendees.

### Event Sponsor
~~US$6,000~~ SOLD OUT

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Recognition as event sponsor and company logo on all event signage. One full-page 4-color ad in *I&ST* magazine. One 6-foot table at event vendor fair.

## SUNDAY, 8 NOVEMBER 2020

### Golf Outing Tee Sponsor*
US$200 (unlimited)

Sign with company logo placed at one of the 18 holes.

### Golf Outing Beverage Cart Sponsor*
US$500 (unlimited)

Sign with company logo on each of the beverage carts.

### Welcome Reception Signature Sponsor
US$2,200 (1 available)

Premium signage during Sunday's welcome reception.

### Welcome Reception Associate Sponsor*
US$200 (unlimited)

Company name on signage during Sunday's welcome reception. Welcome reception is for all attendees.

## MONDAY, 9 NOVEMBER 2020

### Breakfast Sponsor
US$2,200 (1 available)

Premium signage during breakfast. Company logo and recognition as event sponsor on all tables throughout breakfast area.

### Morning Break Sponsor
US$1,500 (2 available)

Premium signage during morning break.

### Lunch Sponsor
~~US$3,500~~ SOLD OUT

SYSTEMS SPRAY-COOLED

Premium signage during lunch and on all tables throughout the luncheon area.

## MONDAY, 9 NOVEMBER 2020 (CONT'D)

### Afternoon Break Sponsor
US$1,500 (2 available)

Premium signage during afternoon break.

### Reception Signature Sponsor
~~US$2,200~~ SOLD OUT

ThermoFisher SCIENTIFIC

Premium signage and acknowledgment as sponsor during Monday's reception.

### Reception Associate Sponsor*
US$200 (unlimited)

Company name on signage during Monday's reception. Reception is for all attendes.

## TUESDAY, 10 NOVEMBER 2020

### Breakfast Sponsor
US$2,200 (1 available)

Premium signage during breakfast. Company logo and recognition as event sponsor on all tables throughout breakfast area.

### Morning Break Sponsor
US$1,500 (2 available)

Premium signage during morning break.

### Lunch Sponsor
US$3,500 (1 available)

Premium signage during lunch and on all tables throughout the luncheon area.

Sponsorships denoted with * will be promoted exclusively during Western Conference functions. All proceeds go to the AIST Southern California Member Chapter.

AIST's nine Technology Divisions are comprised of 30 volunteer-based Technology Committees populated by AIST members with similar technical interests. Technology Committee members are actively engaged in a variety of activities, such as:

- Meetings.
- Technical exchanges.
- Plant tours.
- Development of technical publications and conference programming.
- Industry surveys.
- Industry Roundups.

Technology Committee membership offers many benefits, including:

- An enhanced network of peers.
- A forum to collectively solve problems.
- Opportunities to advance individual technical know-how.

**Committee enrollment is free and open to any AIST member. Join a committee today!**

To join one or more committees, visit AIST.org
or contact:
Anna Voss
manager — technology programs
avoss@aist.org




## Technology Divisions and Technology Committees

### I. Safety & Environment
- Safety & Health
- Environmental

### II. Cokemaking & Ironmaking
- Cokemaking
- Ironmaking
- Direct Reduced Iron

### III. Steelmaking
- Electric Steelmaking
- Oxygen Steelmaking
- Specialty Alloy & Foundry

### IV. Refining & Casting
- Ladle & Secondary Refining
- Continuous Casting

### V. Rolling & Processing
- Hot Sheet Rolling
- Cold Sheet Rolling
- Galvanizing
- Tinplate Mill Products
- Plate Rolling
- Long Products
- Pipe & Tube
- Rolls







VI. **Metallurgy**

- Metallurgy —Steelmaking & Casting
- Metallurgy — Processing, Products & Applications

VII. **Energy, Control & Digitalization**

- Energy & Utilities
- Electrical Applications
- Digitalization Applications

VIII. **Plant Services & Reliability**

- Project & Construction Management
- Maintenance & Reliability
- Lubrication & Hydraulics
- Refractory Systems

IX. **Material Movement & Transportation**

- Material Handling
- Cranes
- Transportation & Logistics


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**COVID-19:** The health and safety of our industry is a shared responsibility and one that we take seriously. As of press time, AIST is actively monitoring the COVID-19 crisis as it may necessitate the postponement or cancellation of some events. Please visit AIST.org for updates or contact us at memberservices@aist.org.

## SUMMER 2020

### DIGITAL TRANSFORMATION OF THE STEEL INDUSTRY
WEEKLY WEBINAR SERIES

## SEPTEMBER 2020

### SHEET PROCESSING AND FINISHING LINES
A PRACTICAL TRAINING SEMINAR
27 September–1 October
Sheraton Indianapolis City Centre Hotel, Indianapolis, Ind., USA

### 27TH AIST CRANE SYMPOSIUM
29 September–1 October *New Dates!*
Omni William Penn Hotel, Pittsburgh, Pa., USA

## OCTOBER 2020

### SECONDARY STEELMAKING REFRACTORIES
A PRACTICAL TRAINING SEMINAR
6–8 October
Holiday Inn Nashville Vanderbilt, Nashville, Tenn., USA

### CONTINUOUS CASTING
A PRACTICAL TRAINING SEMINAR
13–15 October
Holiday Inn Cleveland South - Independence, Independence, Ohio, USA

### ENVIRONMENTAL SOLUTIONS: MEETING EPA AIR EMISSION REQUIREMENTS
19–21 October
Dearborn, Mich., USA

### STEEL MILL COMBUSTION AND THERMAL SYSTEMS
27–29 October
AIST Headquarters, Warrendale, Pa., USA

## NOVEMBER 2020

### THE MAKING, SHAPING AND TREATING OF STEEL: 101
4–5 November
AIST Headquarters, Warrendale, Pa., USA

## FEBRUARY 2021

### MAINTENANCE SOLUTIONS: FUNDAMENTALS AND NEW FRONTIERS
24–26 February *New Dates!*
Embassy Suites Riverwalk, San Antonio, Texas, USA

## MARCH 2021

### DIGITAL TRANSFORMATION FORUM FOR THE STEEL INDUSTRY
15–17 March
Omni William Penn Hotel, Pittsburgh, Pa., USA

## JUNE 2021

### INTERNATIONAL CONFERENCE ON ADVANCES IN METALLURGY OF LONG AND FORGED PRODUCTS
27–30 June *New Dates!*
Vail Marriott Mountain Resort, Vail, Colo., USA


## ABOUT THE WEBINAR SERIES

Digital Transformation is a critical component for steel companies' future success. It is a broad concept with the potential to influence all aspects of the steelmaking process. Following the success of last year's Digital Transformation Forum focusing on an overview of and insight into different components of Industry 4.0, the Digital Transformation of the Steel Industry webinar series dives into the specific topics of machine learning (ML) and artificial intelligence (AI). Machine learning and artificial intelligence technology is the heart of nearly every application of Industry 4.0. The webinar series covers ML/AI applications and use cases from liquid steel (iron- and steelmaking), upstream (casting and hot rolling) and downstream process, to final product. In addition, the webinar series will discuss the essential roles humans are playing in a successful digital transformation journey. Strategies and methods to efficiently manage the cultural change and human involvement are also explored through the high-quality presentations.

## WHO SHOULD ATTEND

Decision-makers and those with a technical background who are interested in learning more about how to make their areas smarter by utilizing digital transformation methods through system integration and ML algorithm deployment.

## HOW TO ATTEND

The Digital Transformation of the Steel Industry webinars are open and free for everybody to attend, members as well as non-members. Register online at AIST.org/conference-expositions/webinars. Presenter-approved on-demand videos will be available at AIST.org following each webinar.

## ORGANIZED BY

AIST's Electrical Applications/Sensors Subcommittee and Digitalization Applications Technology Committees.

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# DIGITAL TRANSFORMATION OF THE STEEL INDUSTRY

Webinar Series

## MACHINE-LEARNING APPLICATIONS FOR PROCESS CONTROL AND OPTIMIZATION IN STEELMAKING

Wednesday, 5 August 2020 (10 a.m. EDT)
Giovanni Bavestrelli, Tenova S.p.A.

This webinar discusses initiatives applied to the control and optimization in steel production plants:

- Application of machine learning (ML) to predict metallization and carbon content in a direct reduction plant.
- Application of convolutional neural networks for automatic classification of scrap material in a steel plant.
- Application of ML to data from a basic oxygen furnace.
- Application of ML to control cassette penetration and strip tension in a tension leveler machine.
- Model to predict NOx emissions in a walking beam furnace.

## INTEGRATED PRODUCTION MANAGEMENT AND QUALITY IN THE AGE OF INDUSTRY 4.0

Wednesday, 12 August 2020 (10 a.m. EDT)
Heiko Wolf, PSI Metals GmbH

This webinar discusses system architecture with the integrated production management system (PMS) as the platform for innovation. Furthermore, the presentation will highlight how an integrated PMS can evolve to enable new use cases with the example of a novel integrated quality management system.

## DIGITALIZATION AND THE DOUBLE-EDGED SWORD: TRANSPARENCY

Wednesday, 19 August 2020 (10 a.m. EDT)
Thomas Pfatschbacher, Primetals Technologies Austria GmbH

The implementation of digitalization systems in the steel industry has a significant potential to improve the overall productivity and stability in steel production. The foundation for these improvements is first to generate a high transparency of production and quality. Data is used to generate key performance indicators and is coupled with human expertise and artificial intelligence to realize intelligent digitalization systems. But this full transparency is not always welcome at all levels of operators and experts. This webinar shows an example of an intelligent digitalization system and deals with cultural topics.

### Did You Know?

**You Can View Past AIST Webinars on AIST.org**

Over the spring and summer, AIST's Technology Committees hosted a variety of free webinars, covering various aspects of steelmaking technologies. Past webinar videos include:

- How AI Is Increasing Production Quality in Steel Manufacturing
- Ironmaking With Alternative Reductants
- Making Sense of Maintenance 4.0
- Merging Process Knowledge and Artificial Intelligence to Find Hidden Value, Part 1
- Planning For Success — Project Baseline Scope and Budget Development and Management
- Production, Storage and Safe Handling of Hydrogen
- Technology-Driven Industrial Troubleshooting
- You Asked For It: Your Questions Answered About SBQ Bar Cold Finishing

Visit AIST.org today to check out free webinars relevant to your work in today's steel industry!


**PLANT TOUR: STEEL DYNAMICS INC. – FLAT ROLL GROUP HEARTLAND DIVISION**

## ABOUT THE PROGRAM

This seminar will provide a comprehensive overview of process lines, including pickling, annealing, galvanizing, cleaning, plating, painting, skinpass rolling, leveling, slitting and special processes. This seminar will also focus on terminal equipment for the entry and exit sections, strip quality assessment, industrial hygiene, safety, environmental concerns, overview of modeling for design and line control, operations, maintenance, and factors to consider in configuring a new process line. There will be many opportunities to discuss issues and solve problems during the question-and-answer periods.

## WHO SHOULD ATTEND

Those who would like to expand their knowledge and understanding of process lines: new and transferred employees of steel producers; mechanical, electrical, process and metallurgical engineers; software and process control personnel; maintenance personnel; operators; and quality assurance specialists. Equipment manufacturers, employees from steel processors and steel service centers, suppliers, and customers of steel producers will also benefit from this seminar.

## REGISTRATION INCLUDES

Welcome reception Sunday, breakfast and lunch Monday–Thursday, reception Tuesday, plant tour with bus transportation, and a course workbook or flash drive including presentations.

## HOTEL ACCOMMODATIONS

A block of rooms has been reserved at the Sheraton Indianapolis City Centre Hotel. Please call the hotel at +1.888.236.2427 by 4 September 2020 to secure the AIST discount rate of US$149 per night for single/double occupancy.

## ORGANIZED BY

AIST's Rolling and Processing Technology Division.

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# SHEET PROCESSING AND FINISHING LINES

A Practical Training Seminar

## SUNDAY, 27 SEPTEMBER

- Registration
- Reception (5 p.m.)

## MONDAY, 28 SEPTEMBER

Morning Sessions (8 a.m.)

- Introduction, Opening Remarks
  Chad Donovan, SMS group Inc.

- Overview and Definition of General Terms
  Chad Donovan, SMS group Inc.

- Take Control of Safety
  Wendy Selph, Steel Dynamics Inc. – Flat Roll Group Heartland Division
  Proactively identifying and controlling incidents that have the potential to cause significant injuries or fatalities.

- Process Line Design Fundamentals
  Dave Withrow, Allor Manufacturing Inc.
  To ensure the success of a process line, its performance requirements must be integrated fully with its setting, and the strip driving power must be ample.

- Incoming Material
  Mark Zipf, SMS group Inc.

Afternoon Sessions (1 p.m.)

- Annealing
  Bill Lucas, Fives ST
  This session will consider various aspects of steel annealing as it pertains to strip. The reasons for annealing, along with the physical results possible with different thermal cycles, will be covered. Equipment employed along with methods of heating, cooling and strip conditioning will be reviewed in greater detail. A brief discussion of materials used and how they influence equipment lifetime and maintenance is included. Processing atmospheres, equipment control methods and safety considerations are also discussed.

- Skinpass/Temper Rolling
  Mark Zipf, SMS group Inc.
  This presentation provides an overview of skinpass and temper rolling, with an emphasis on "why we are doing this" and "how all this works." Starting with a study of the material's yielding and deformation behavior, the strip's surface structure, and the concepts of profile, shape and flatness, an understanding of the key factors is established, warranting the rolling deformation process and governing its objectives. Next, classical rolling mill arrangements are reviewed, and the discussion examines the force-loaded conditions/reactions occurring within the roll bite. The mill's equipment is then dissected with a focus on the general arrangement and roll gap/shape actuators, combined with the mill's control strategies and systems. Methods of performance measurement/quality evaluation are introduced. The presentation closes with a comparison of differing mill formats and a review of recent developments in enhanced quality and productivity.

- Cut-to-Length/Leveling Lines
  Greg Santillo and Tom Uhric, ANDRITZ Herr-Voss Stamco Inc.

Adjourn (5 p.m.)

## TUESDAY, 29 SEPTEMBER

Morning Sessions (8 a.m.)

- Continuous Hot-Dip Galvanizing
  Gary Dallin, International Zinc Association
  Presentation on the coating section of a modern hot-dip zinc coating line, including bath control, zinc wiping practices and galvanneal production.

- Slitting and Sidetrimming
  Greg Santillo, ANDRITZ Herr-Voss Stamco Inc.
  This presentation will feature a description of the slitting/sidetrimming process, typical layout and operation considerations. Challenges of market trends (materials, legislation) on designs and new solutions derived from these will also be discussed.

- Tinplating — As Relevant Now as Ever
  Vikram Trehan, Tata Steel
  In the production of tinplate, the steel base and the application of the tin coating are independent of each other so that theoretically any tin coating, or combination of coatings, may be applied to any steel base. Thus the range of materials classified as tinplate can run into many thousands. Indeed, tinplate is available in more qualities than virtually any other light-gauge sheet metal product.

- Paint Lines
  Nikhil Kulkarni, Steel Dynamics Inc. – Flat Roll Group Jeffersonville Plant

Afternoon Sessions (12:30 p.m.)

- Plant Tour of Steel Dynamics Inc. – Flat Roll Group Heartland Division

- Reception (5 p.m.)

# SHEET PROCESSING AND FINISHING LINES (cont'd)

A Practical Training Seminar

## WEDNESDAY, 30 SEPTEMBER

Morning Sessions (8 a.m.)

- Coil Joining Using Resistance Welding
  Matt Keller, Taylor-Winfield Technologies Inc.
  This presentation gives an overview of processes and equipment utilized in the coil joining process in sheet processing and finishing lines, including resistance seam and spot, plasma, and metal inert gas (MIG).

- Laser Welding for Coil Joining
  Deni Bellai, Hugo Miebach GmbH
  The presentation will cover coil joining using a laser for welding. It will look at key differences for this type of welding machine from other types available, and will provide details on the process and the benefits it provides over other technologies.

- Weld Inspection
  Alexandre Nadeau, Tecnar Automation
  This presentation will cover the various methods used for weld inspection (electromagnetic acoustic transducer ultrasonic testing (UT), laser UT, pyrometry, profilometers). The advantages and inconvenience of using these technologies will be explained. The presentation will also cover the type of welds for which they are more useful. Finally, an approximate budget range for purchase and operation will be presented.

- Pickling — Carbon and Stainless Steel
  Jay Kremm, Danieli Corp.

- Cleaning Section Process Technology
  David Thiemann, Atlantech Process Technology Inc.
  This presentation will describe in detail each unit and its process function in the cleaning section.

- The Chemical Process of Steel Strip Cleaning and How to Enhance Performance
  Stephanie Williamson, Quaker Houghton
  Steel strip undergoes cleaning for the removal of process fluids, metal fines and surface residue prior to various downstream processing and finishing applications. A clean metal surface is necessary for these applications, which include annealing, metallic coating and painting. Before enhancing cleaning performance, it's important for operating personnel to understand the general framework for chemical and mechanical strip cleaning. Once this general framework is learned, ways to optimize cleaner performance through solution chemistry control and equipment design will be discussed.

Afternoon Sessions (1 p.m.)

- Acid Regeneration

- Conversion Coatings: Oiling, Phosphate, Chromate, Plating, Acrylic
  Stephanie Williamson, Quaker Houghton

- Control Basics
  John Ingram, Primetals Technologies USA LLC
  This presentation will describe programmable logic control of various actuators within processing lines. Human-machine interface and safety concepts will also be discussed.

- Automated Surface Inspection of Sheet and Finished Product
  Greg Gutmann, ISRA Surface Inspection
  Gain an understanding of automated surface inspections, what a system consists of, what it does that a human cannot do and the benefits of deploying a system. Receive a basic introduction to camera technologies of line and area scan and how defects are detected and defined. Learn how an automated inspection system can be deployed in the production environment of sheet processing and finishing lines. Understand new technologies that are being developed to deploy automated inspection systems where they have previously been blocked by space or the environment.

- Flatness Measurement and Control
  Brian Smith, ANDRITZ Herr-Voss Stamco Inc.
  This presentation gives an introduction into the overall shape/flatness control problem.

- Question-and-Answer Session

## THURSDAY, 1 OCTOBER

Morning Sessions (8 a.m.)

- Slitting Mechanics and Slitter Tooling for Modern Metal Processing
  Brian Shaw and Jim Robbins, ANDRITZ ASKO Inc.
  The practical application of basic engineering principles to sidetrimming and slitting all gauges and grades of steel ranging from interstitial-free steel to advanced high-strength steel. This presentation will equip attendees with the knowledge to be able to evaluate a cut metal edge with respect to a customer's quality requirements and understand what knife adjustments are needed to meet the requirements.

- Predictive and Preventive Maintenance
  David Fulford, Steel Dynamics Inc. – Flat Roll Group Heartland Division
  Equipment reliability is essential to any successful business, particularly in the steel industry. Thousands of dollars are lost when steel processing equipment fails. This presentation will summarize preventive and predictive maintenance practices adopted at Steel Dynamics Inc. – Flat Roll Group Heartland Division to maximize equipment reliability.

- Duty Cycle and Other Considerations

  Rich Warriner, Virginia Crane - Foley Material Handling Co. Inc.

  There are a number of factors to be considered when specifying the correct crane design for each application. This paper reviews those criteria.

- Packaging of Coils and Sheets

  Dan Abrell, Fleetwood-Signode, a division of Signode Industrial Group

  This presentation will outline the methods of packaging historically and how they have changed. Discuss will briefly focus on the typical mill package, but will primarily focus on service centers.

- Shipping

  Bruce Zimmerman, Nucor Steel–Indiana

Afternoon Session (1 p.m.)

- Strip Quality Panel Discussion

  Moderator:

  Mark Marietti, AK Steel – Dearborn Works

  Panelists:

  Nikhil Kulkami, Steel Dynamics Inc. – Flat Roll Group Jeffersonville Plant

  Kevin Siebeneck, United States Steel Corporation

  Stavros Fountoulakis, ArcelorMittal Global R&D

Conference Adjourn (3 p.m.)


## ABOUT THE PROGRAM

The symposium will deliver practical information and experiences from crane maintenance personnel, crane manufacturers, equipment manufacturers and engineering consultants who strive to make electric overhead traveling (EOT) cranes and their runways the safest, most reliable, durable machinery and equipment in the industry. This two-day program will include presentations focused on safe work practices and ergonomics; electrical, mechanical and structural maintenance techniques; crane automation technologies; and best practices in EOT crane modernizations. As part of the Crane Symposium program, the Charlie Totten Crane Innovator Award winner will be announced, recognizing the individual who has brought forth the latest in technology, or increased efficiencies in operational and maintenance practices for the continuous improvement of heavy industrial cranes.

## WHO SHOULD ATTEND

Plant maintenance staff; applications, electrical, mechanical, safety, service and design engineers; operations and maintenance personnel and management; and those people who supply parts, equipment and services to the industry. Anyone who has responsibility for cranes and crane service and is interested in improvements and incidents in this area should attend.

## REGISTRATION INCLUDES

Tuesday reception, breakfast and lunch Wednesday and Thursday, a dinner Wednesday evening, and a course workbook or flash drive including presentations.

## HOTEL ACCOMMODATIONS

A block of rooms has been reserved at the Omni William Penn Hotel. Please call the hotel at +1.800.843.6664 by 15 September 2020 to secure the AIST discount rate of US$175 per night for single/double occupancy.

## ORGANIZED BY

AIST's Cranes Technology Committee.

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Event Sponsors SES MORGAN ENGINEERING

## 27TH CRANE SYMPOSIUM

## TUESDAY, 29 SEPTEMBER

- Registration

- Welcome Reception (5 p.m.)

## WEDNESDAY, 30 SEPTEMBER

Morning Sessions (8 a.m.)

- 2020 Charlie Totten Crane Innovator Award: Crane Magnet Reliability: Methods of Monitoring Crane Magnet System Operation and Condition
  Brian Kath, Nucor Steel–Berkeley
  Magnet systems are critical tools for many applications in the steel industry. Magnet failures place employees at risk, and can cause damage and impact productivity. This presentation offers some tools that can be used to verify that design parameters are not being exceeded and determine the operational health of the complete magnet system.

- Crane Safety — We've Done the Thinking So You Don't Have To
  Kevin Hoffmeyer, Whiting Corp.
  This paper will review the importance of crane runway maintenance as it applies to safety, cost of ownership and reliability. It will share examples of impacts and data analysis used to identify root cause and offer means of mitigating through robust preventive maintenance programs.

- Why Crane Runways Don't Have Capacities
  Alex Tadla, Simmers Crane Design & Services Co.
  A discussion of the many variables at play in crane loading on runways. The number of cranes, wheels, wheel base, crane spacing, etc., all have a major impact on the ability of the runway to support cranes of varying capacities in multiple scenarios.

- Important Updates to *AIST Technical Report No. 13*
  Tim Bickel, CSD Structural Engineers
  *AIST Technical Report No. 13 — Guide for the Design and Construction of Mill Buildings* was published in 1969 to provide owners, engineers and contractors with information about the considerations unique to mill buildings. The 6th edition is being prepared for release and includes many important updates, including:
  - Crane load cases and combinations to match current building code requirements.
  - Updated crane runway girder design criteria.
  - Expanded crane runway fabrication and erection tolerance requirements.
  - An expanded section with guidance on structural inspections and reinforcement.

  This session will further explain these updates and the benefits to building owners.

- Redundancy, Emergency Brake in Hot Metal Cranes/Steel Mills
  Max Pauli, SIBRE Brakes GmbH
  This paper will provide an introduction to emergency brakes, including their design and function; why to use emergency brakes; and different types — hydraulic, magnetic, pneumatic. It will also cover redundancy in cranes. Why redundancy? To provide a comparison to other cranes where it is already used; European standards for cranes; steel mills are more sensible than port areas; and accident prevention.

- Flat-Tread vs. Tapered-Tread Wheels Revisited
  Rich Warriner, Virginia Crane - Foley Material Handling Co. Inc.
  A condensed comparison of two previous presentations by proponents of both designs. This presentation is designed to provide attendees with information to determine which design is best for their application.

- The Making, Shaping and Treating of Crane Wheels
  Mark McGinley, Hall Industries Inc.
  This presentation describes the material selection, production processes, heat treating practices, and inspection procedures commonly used in the production of crane wheels and wire rope sheaves.

Afternoon Sessions (1 p.m.)

- Mill Roll Handling — Challenges, Equipment and Safety Considerations
  James Annab, Bradley Lifting
  This presentation will explore the challenges associated with mill roll handling, including efficiency and considerations for facilities with a large variety of roll configurations. It will also cover some of the equipment options available to handle the variety of different roll and chock configurations, as well as best practices for determining a solution that fits the end user's process. Finally, it will cover some of the guidelines of safe mill roll handling, and the role that "hands off" handling plays in ensuring safety for personnel.

- Identifying a Disaster Crane Project Before It Happens
  Larry Dunville and Tad Dunville, Overhead Crane Consulting LLC
  Crane projects can be classified by Pareto's 80/20 Rule. About 80% are simple cranes, while 20% are projects you wish you had

## 27TH CRANE SYMPOSIUM (cont'd)

never seen. This presentation will identify three factors that separate the 80 from the 20 and will examine how to avoid the 20% and what to do in a 20% cluster situation.

- Increasing the Life of a Trolley Gear Drive by Changing the Gear Geometry and Bearing Style Without Changing the Gear Drive Housing
  Bill Schierenbeck, Xtek Inc.
  A gear drive that experienced frequent bearing changes in its first 4 years of service underwent a design change and has experienced zero bearing-related issues in the past 5 years.

- Improving Encoder Reliability in Overhead Cranes
  Brian Winter, Nidec Industrial Solutions
  Encoder operation is critical to maintaining uptime in overhead cranes. This seminar will cover troubleshooting and preventive maintenance that can reduce or eliminate encoder-related downtime.

- Innovations in Crane Technology
  Mike Martin, Trutegra
  This presentation will cover emerging technologies to aid operators with manual and semi-auto cranes as well as new technologies for fully automatic operation. Manual/semi-auto new technology includes anti-sway for non-variable frequency drive cranes, obstacle avoidance/no-fly zones, and the use of augmented reality. New automated crane technology includes automatic bucket crane digging, real-time obstacle avoidance of moving material, automated eye-to-the-sky coil handling, and programmable logic controller-based 3D mapping of bulk inventory.

- Adding Intelligent Technology to Your Overhead Crane
  Jim Kluck, Columbus McKinnon Corp./Magnetek
  The overhead crane is the heart of production operations. Incorporating intelligent automated solutions can increase the safety, productivity and uptime of a facility. A quick return on investment through intelligent motion- and technology-enabled lifting devices can be provided by predictive maintenance, faster times to recover from a fault, increased equipment and operator safety, and detailed application information on the factory floor. This presentation will introduce concepts and technology to show how to bring intelligence to the operation of overhead cranes.

- Dinner (5:30–9 p.m.)

## THURSDAY, 1 OCTOBER

Morning Sessions (8 a.m.)

- Monitoring for Overhead Crane Collisions With In-Plant Storage Racking and Movable Obstacles
  Phillip Prokop, Laser-View Technologies

- High-Speed Data Transmission Rail for Automated Cranes
  Pete Kirst and Brian Roberts, Conductix-Wampfler

- Use of Non-Contact Sensors to Provide and Improve Safety and Reliability in the Operation of Overhead Cranes
  Steven Lubeck, Laser-View Technologies
  Traditionally, overhead cranes have utilized mechanical means of providing safety features. Sensor technologies exist that provide non-contact solutions to applications previously handled with mechanical methods. Non-contact solutions are more reliable and provide a level of operational flexibility not possible with traditional methods. This presentation will provide descriptions of various non-contact sensing methods. New techniques will also be discussed. Emphasis will be placed on the level of reliability and safety provided by each method, along with the relative levels of complication related with the integration. Examples will be provided with the intent of sparking interest in creative approaches to using sensors on cranes to establish safer and more reliable operation.

- Optimizing Material Handling
  Rob Loomis, InVekTek LLC
  The throughput of a plant is throttled by the skills of the least experienced crane operator. The recent resurgence of the steel industry and the sudden increase in new hires has magnified the need to help new crane operators get up the learning curve. One industry leader reported it incurs US$1.5 million per month in product damage due to operator error and it's getting worse. While viable automation is still not yet attainable, there are new technologies that can dramatically save money by accelerating the learning curve of new crane operators, reducing the number of and severity of collisions and improving overall productivity.

- Automatic Coil Crane With Railroad Coil Removal at Nucor Gallatin
  Edgardo La Bruna, Janus Automation, and Dave Reynolds, Nucor Steel Gallatin
  Implementation of an automatic storage and retrieval system with the functionality to automatically remove coils from railroad cars at Nucor Steel Gallatin. This paper will present state-of-the-art automation and safety functions, including housekeeping operation, no-fly zones, intelligent positioning, detection of objects and area access.

- 34T ROS Scrap Crane Installation and Operation
  Michael Sauer, Charter Steel – Saukville
  This presentation discusses the installation and start-up challenges and rewards related to Charter Steel's first crane to be run from a remote operating station. It will provide a summary of what was learned during the first year of operation.

### - Implementation of Crane Automation Features

Edgardo La Bruna, Janus Automation, and Robbie Sturgill, Steel Dynamics Inc. – Flat Roll Group Columbus Division

This presentation discusses real cases of crane automation features at Steel Dynamics Inc. – Flat Roll Group Columbus Division. New technology allows the reliable implementation of crane automation features even in harsh environments. Some of the crane automation features are simple anti-collision, no-fly zone and slow-down zones, positioning assistance, closed loop anti-sway, semiautomatic positioning, automatic operation, automatic storage and retrieval systems, and logistics optimizer and diagnostics tools. The incorporation of crane automation features increases productivity and also safety. This presentation discusses key aspects and recommendations for successful projects.

### - How to Give a Technical Presentation

Tom Berringer, Gantrex Inc.

### Conference Adjourn (12:30 p.m.)

# SECONDARY STEELMAKING REFRACTORIES

## A PRACTICAL TRAINING SEMINAR

## 6–8 OCTOBER 2020

HOLIDAY INN NASHVILLE VANDERBILT • NASHVILLE, TENN., USA

**PLANT TOUR: GKN-HOEGANAES CORP.**

## ABOUT THE PROGRAM

Secondary steelmaking refractory maintenance is vital to both productivity and safety in a meltshop and caster. It is important for those involved to have a thorough understanding of the basic concepts of refractory system design. Consultants, suppliers and recognized industry experts have developed a curriculum to educate attendees on the following topics: refractory raw material selection; properties of refractories, application and limitations of refractories; theory and application of insulation; design and application of stir plugs, lances and slidegates; free opens, refractory handling, installation and pre-heating; ladle secondary steelmaking — LMF; and casting requirements and wear mechanisms.

Presentations will provide data from steelmaking operations, and attendees will benefit from the practical experience of the presenters, including the application of the latest tools and techniques being used. Open discussions will allow participants to gather additional information and network with attendees and instructors.

## WHO SHOULD ATTEND

This conference is intended for steelmaking operations personnel, maintenance and supervisory employees. Refractory suppliers and service suppliers should also attend. The AIST Ladle & Secondary Refining and Refractory Systems Technology Committees strongly believe that this course provides the basic knowledge for a better understanding of secondary steelmaking, refractory and insulating systems.

## REGISTRATION INCLUDES

Tuesday and Wednesday breakfast and lunch, Tuesday reception, Thursday breakfast, plant tour with bus transportation, and a course workbook or flash drive including presentations.

## HOTEL ACCOMMODATIONS

A block of rooms has been reserved at the Holiday Inn Nashville Vanderbilt. Please call the hotel at +1.877.327.4707 by 14 September 2020 to secure the AIST discount rate of US$169 per night for single/double occupancy.

## ORGANIZED BY

AIST's Ladle & Secondary Refining and Refractory Systems Technology Committees.

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## SECONDARY STEELMAKING REFRACTORIES

A Practical Training Seminar

## MONDAY, 5 OCTOBER

- Registration (4 p.m.)

## TUESDAY, 6 OCTOBER

Morning Sessions (8 a.m.)

Keynote Presentation

- Raw Materials, Bricks and Shapes, and Monolithics
  Ruth Engel, Refractory Consulting Services
  The seminar will begin by presenting the raw materials used in the manufacture of refractories, why they are used, their availability and characteristics. Using this information, the raw materials will be combined to make bricks or shapes and the role the different components play on their properties will be discussed. This discussion will extend to monolithics, where parameters like installation and dryout will be covered.

- Refractory Brick Production
  Korey Skala, HarbisonWalker International
  Production of refractory bricks from raw material to finished product.

- Ladle Construction Design and Insulation
  Rob Doty, IMACRO Inc.
  This presentation will discuss the many options in ladle refractory design. The basics of heat transfer will then be covered, from molten steel through refractories to ladle shells, followed by insulation choices, how they affect ladle shell temperatures and refractory expansion dynamics.

Afternoon Sessions (1 p.m.)

- Ladle Pre-Heat and Handling
  Jimmy Barrett, Allied Mineral Products Inc.
  Steel ladles will be covered in detail, including pre-heating, refractory wear mechanisms and measuring options.

- Ladle Burner Technology and Controls
  Dale Smith, Honeywell Combustion Safety

- Tap-to-Cast Operations
  Harriet Dutka, SANGRAF International
  This presentation is a brief overview that focuses on answering the "whys" of certain practices and procedures in steelmaking. If you are new to steelmaking or are in a non-technical role, this presentation will answer many of the questions you would like to ask.

- Panel Discussion and Reception
  Moderator:
  Jimmy Barrett, Allied Mineral Products Inc.
  Panelists:
  Rob Doty, IMACRO Inc.
  Harriet Dutka, SANGRAF International
  Helmut Oltmann, Nucor Steel–Berkeley

Adjourn (5 p.m.)

## WEDNESDAY, 7 OCTOBER

Morning Sessions (8 a.m.)

- Safety: Past/Present/Future
  John Panconi, BISCO Refractories Inc.
  A view of where we were with safety, how things are now and what the future holds.

- Refractory Materials Testing and Product Selection
  Rakesh Dhaka, U. S. Steel Research and Technology Center
  Standard test methods and their application in evaluating and selecting refractory materials will be discussed.

- Secondary Steelmaking Process — LMF
  Helmut Oltmann, Nucor Steel–Berkeley
  This presentation provides a review of the ladle metallurgy furnace processes to modify chemistry and temperature of the steel in the ladle and their impact on refractories.

- Advancements in Infrared Technology
  John Lewis, Connors Industrials Inc.
  This presentation will cover an examination of newly developed infrared technologies for practical secondary processing applications.

- Ladle Laser Program
  Michael Bonin, Vesuvius

Afternoon Sessions (1 p.m.)

- Stir Plugs, Lances, Slidegates and Tundish Gates

- Tundish Refractory
  Fred Adkins, HarbisonWalker International
  This presentation will focus on tundish design. It will cover the composition design of the refractory lining materials, the design of the arrangement of flow modifiers, and the effect they have on steel and the way it is processed in the tundish.

- Principles of Mold Flux Technology

- Flow Control Products
  Josh Kaser, RHI Magnesita
  This presentation will focus on isostatic refractories that are used at the caster during continuous casting.

Adjourn (5 p.m.)

## THURSDAY, 8 OCTOBER

Morning Sessions (8 a.m.)

- Plant Tour of GKN-Hoeganaes Corp.

Conference Adjourn (Noon)


PLANT TOUR: TIMKENSTEEL CORP. OR ARCELORMITTAL CLEVELAND

## ABOUT THE PROGRAM

Developed and presented with the talented resources of the Continuous Casting Technology Committee, this informative program targets the heart of steelmaking: the frontline operator. The key focus of the program is to discuss the practical aspects of casting slabs, billets and blooms, while introducing the theoretical concepts. By achieving the proper teaching balance, attendee understanding of the process is ensured without the need for a technical background. This course is a must for the progressive, informed and educated steelmaker of the future!

## WHO SHOULD ATTEND

This training seminar has been designed for the frontline casting employee. It would also be beneficial to individuals newly assigned to work in the casting area, suppliers of casting consumables and services, as well as others wishing to review major variables that impact the quality of as-cast products. The presentations will be geared toward general casting principles, with all machine types represented.

## REGISTRATION INCLUDES

Breakfasts and lunches Tuesday and Wednesday, reception Wednesday, breakfast Thursday, plant tour with bus transportation, and a course workbook or flash drive including presentations.

## HOTEL ACCOMMODATIONS

A block of rooms has been reserved at the Holiday Inn Cleveland South - Independence. Please call the hotel at +1.216.524.8050, ext. 298 by 19 September 2020 to secure the AIST discount rate of US$105 per night for single/double occupancy.

## ORGANIZED BY

AIST's Continuous Casting Technology Committee.

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## CONTINUOUS CASTING

A Practical Training Seminar

## MONDAY, 12 OCTOBER

- Registration (4–6 p.m.)

## TUESDAY, 13 OCTOBER

Morning Sessions (8 a.m.)

- Historical Perspective of Continuous Casting

- Continuous Casting Design and Technology (Slab and Long Products)

- Principles of Mold Flux Technology — An Operator's Guide to Continuous Casting Flux
  Darrell Sturgill, IMERYS Steelcasting USA Inc.
  Attendees will receive an overview of the design, production and application of continuous casting fluxes.

- Initial Solidification and Oscillation Mark Formation

Afternoon Sessions (1 p.m.)

- Sources of Reoxidation and Why to Avoid
  Ron O'Malley, Missouri University of Science and Technology
  To produce high-quality cast products, steel must be protected from reoxidation. Reoxidation can occur in the ladle, at secondary ladle metallurgy operation, and also in the transfer operations from ladle to tundish and tundish to the mold. Various techniques will be described that can be used to minimize reoxidation.

- Mold Copper Alloys, Mold Design and Influence of Operating Factors on Mold Life
  Ian Bakshi, KME America Inc.
  Information as to the requirements that molds must fulfill when used on a steel continuous casting machine, the copper alloys used, design details, various operation factors that affect mold life and typical mold problems encountered will be presented.

- Caster Quality Defects and Their Potential Causes
  Ron O'Malley, Missouri University of Science and Technology
  The surface and internal quality of continuously cast slabs and billets is intimately linked to the caster design and to the operating and maintenance practices employed in the continuous casting process. Common causes for five classes of continuous casting defects (longitudinal cracking, transverse cracking, slivers and lamination defects, internal cracking, and segregation defects) will be reviewed and linked to these design and practice influences.

Adjourn (5 p.m.)

## WEDNESDAY, 14 OCTOBER

Morning Sessions (8 a.m.)

- Breakouts and Their Prevention
  Bill Emling, SMS group Inc.
  This presentation is based on the chapter in *The Making, Shaping and Treating of Steel, Casting Volume.* A review will be given of various causes for caster breakouts and the systems used to alarm and prevent breakouts.

- Mold and Copper Maintenance and Coating Technologies
  Chad Donovan, SMS group Inc.
  Discussion of the various types of continuous caster molds and proper maintenance practices, including a variety of mold coating options available to the industry.

- Caster Roll Maintenance and Overlay Technologies
  Jeff Brower, Primetals Technologies USA LLC
  Caster roll and segment life can be significantly increased through the use of customized weld overlays and base materials. This session details the operational impact on caster rolls and technologies developed to improve roll performance.

Afternoon Sessions (Noon)

- Plant Tour of TimkenSteel Corp. or ArcelorMittal Cleveland

- Panel Discussion and Reception

Moderator:
Jeff Brower, Primetals Technologies USA LLC

Panelists:
Ian Deeks, Nucor Steel–Arkansas
Ron O'Malley, Missouri University of Science and Technology

Adjourn (5 p.m.)

## CONTINUOUS CASTING (cont'd)

A Practical Training Seminar

## THURSDAY, 15 OCTOBER

Morning Sessions (8 a.m.)

- Billet and Bloom Caster Operations and Maintenance
  Ian Deeks, Nucor Steel–Arkansas
  Lessons learned in the operations of billet and bloom casters.

- Caster Hydraulics — Failure Modes and Preventive Maintenance
  Mark Cook, Yates Industries Inc.
  This discussion will cover cylinders used in casters, failure modes, preventive maintenance and effective cylinder reconditioning programs.

- Caster Secondary Cooling and Water Treatment
  Stephen Swoope, Delavan Spray Technologies, and John Cioffi, NALCO Water, An Ecolab Company
  Overview of spray nozzles used in the casting processes with detailed technical support on selection and maintenance of products used for cooling steel. Using fluid dynamics and heat dispersion to ensure a quality product with the highest productivity rate available today. This presentation will offer basic nozzle types and function. It will also include a look at primary and secondary cooling water leading indicators and best practices for implementation of a successful treatment program.

- Caster Bearings — Types of Bearings, Failure Modes and Preventive Maintenance
  Paul Brda, NSK Corp.
  Types of bearings used in casters, common failure modes and maintenance best practices.

Conference Adjourn (Noon)


PLANT TOUR: NEFCO

## ABOUT THE PROGRAM

Meeting air emissions requirements in the steel industry is a challenging endeavor. Global changes in the steel market and evolving U.S. Environmental Protection Agency regulations have made strategic planning, compliance, monitoring and operations more complex than ever. This conference will focus on technologies, equipment and strategies to help attendees navigate the all-encompassing demands of air emissions capture systems. Case studies highlighted will offer solutions and best practices for increased efficiency at all stages of air pollution control equipment life, including design, operation, maintenance, troubleshooting and upgrades/retrofits. Effective strategies for compliance, data monitoring, reporting and permitting will also be discussed. Equipping attendees with new tools to better evaluate the effectiveness of their systems will be a primary goal of the course.

## WHO SHOULD ATTEND

This course is aimed at engineers; environmental managers; health, safety and environment personnel; strategic planners; and operations/maintenance personnel.

## REGISTRATION INCLUDES

Reception, breakfast and lunch Monday and Tuesday, breakfast Wednesday, plant tour with bus transportation, and a course workbook or flash drive including presentations.

## ORGANIZED BY

AIST's Environmental Technology Committee.

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## ENVIRONMENTAL SOLUTIONS: MEETING EPA AIR EMISSION REQUIREMENTS

### MONDAY, 19 OCTOBER

Morning Sessions (8 a.m.)

- Overview of Control Techniques: What Is Used and Why
- Using Computational Fluid Dynamics to Determine Capture Efficiency
- Capture of Pollutants: Thermodynamics, Plume Behavior and Collection Hoods
- Filter Media and Technologies: Can Bag Selections Affect How EPA Requirements Are Met?

Afternoon Sessions (1 p.m.)

- Baghouse Design Features — Considerations, Overview of Baghouse Cleaning Processes and Reverse Air
- Overview and Evolution of Broken Bag Detectors: Can This Help Meet EPA Requirements?
- Dust Handling — Mechanical Screws, Rotary Valves, Double Dumps, Air Locks and Seals
- Panel Discussion
- Reception (5 p.m.)

Adjourn (6 p.m.)

### TUESDAY, 20 OCTOBER

Morning Sessions (8 a.m.)

- Keys to Effective Evaporative Cooling
- Heat Transfer, Control and the Impact on System Design and Operation
- Fan Fundamentals

Afternoon Sessions (1 p.m.)

- The Nuts and Bolts of Stack Emissions Testing for the Iron and Steel Industry
- Emissions Monitoring Systems for the Steel Industry
- Wet Scrubber Operation and Maintenance
- Unpaved Roadways Fugitive Dust Emissions and Control
- Wrap-Up

Adjourn (4:45 p.m.)

### WEDNESDAY, 21 OCTOBER

Morning Sessions (8 a.m.)

- Plant Tour of NEFCO
- Return From Plant Tour and Conference Adjourn (Noon)


**PLANT TOUR: BLOOM ENGINEERING CO. INC.**

## ABOUT THE PROGRAM

Approximately 20% of the cost of producing steel is energy, and of this, a large component is fuel for thermal processing. Additionally, proper maintenance and operation of the thermal systems in a steel plant have ramifications on safety, profitability, product quality and environmental emissions. The seminar will be held in a classroom setting to encourage active discussion and sharing of experiences among participants.

The goal of the seminar will be to give students the basic knowledge and operating background to assess and understand the condition of their combustion system equipment. Attendees will also be given exposure to the latest techniques for upgrade and optimization of their systems. The relationship of hardware and controls will be highlighted. Case studies and hands-on equipment samples will be provided to complement theoretical analysis. Applied combustion topics such as the use of sensors and diagnostics, advanced energy optimization techniques like thermal recovery and use of pure oxygen, as well as selection of refractory materials will be covered.

## WHO SHOULD ATTEND

This training seminar is designed for supervisors, engineers, and technicians who are directly involved in the operation, maintenance, design or installation of combustion equipment in steel mills.

Other attendees who would benefit from this seminar include risk managers, safety personnel, utility personnel who manage fuels utilization, purchasing personnel who procure utilities and environmental engineers who are responsible for air quality. This training would also benefit the energy engineers/managers who are responsible for energy efficiency and optimization on-site.

## REGISTRATION INCLUDES

Tuesday reception, Tuesday–Thursday continental breakfast and lunch, plant tour with bus transportation, and a course workbook or flash drive including presentations.

## HOTEL ACCOMMODATIONS

A block of rooms has been reserved at the DoubleTree by Hilton Hotel Pittsburgh-Cranberry. Please call the hotel at +1.724.776.6900 by 5 October 2020 to secure the AIST discount rate of US$139 per night for single/double occupancy.

## ORGANIZED BY

AIST's Energy & Utilities Technology Committee.

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## STEEL MILL COMBUSTION AND THERMAL SYSTEMS

## TUESDAY, 27 OCTOBER

Morning Sessions (8 a.m.)

- Combustion and Burner Fundamentals
  Anup Sane, Air Products

- Blowers and Fans
  Jim Conway, New York Blower Co.
  Fundamentals of fan performance, operation and control in combustion systems.

- Helping Address the World's Most Critical Flow Measurement Needs
  David Taplin and Mark Sagstetter, Emerson Automation Solutions
  This presentation will discuss flow measurement best practices and review common precision flow measurement technologies.

- Combustion System Reliability Improvements Disguised as Safety Code Compliance
  John Puskar, Prescient Technical Services LLC
  For those who operate fuel-fired equipment, NFPA 86, The Standard for Ovens and Furnaces, should be their best friend. Embracing compliance can result in safer operations, improved reliability and energy savings. This standard applies to all ovens and furnaces within steelmaking and processing facilities. In addition to covering other major parts of the standard, best practices will be provided that describe reliability enhancements to design failure out of combustion systems and fuel trains.

Afternoon Sessions (1 p.m.)

- Combustion System Maintenance

- Combustion Control Components/Hardware/Burner Management Systems

- Solving Your Burning Problems: Combustion Sensors and Diagnostics
  Vi Rapp, Lawrence Berkeley National Laboratory
  This presentation will review important process variables and related sensors needed to evaluate and diagnose a combustion system. Specifically, this presentation will discuss how to use the equipment to control the combustion process and how to diagnose potential problems. It will also include an overview of technologies and equipment used at Berkeley Lab.

- Environmental Emissions
  Michael Cochran, Bloom Engineering Co. Inc.

- Reception at DoubleTree by Hilton Hotel Pittsburgh-Cranberry

Adjourn (5:45 p.m.)

## WEDNESDAY, 28 OCTOBER

Morning Sessions (8 a.m.)

- Advanced Energy Optimization Heat Recovery Systems Oxy-Fuel Combustion
  Michael Cochran, Bloom Engineering Co. Inc.
  This talk will explore existing techniques to enhance energy efficiency.

- Role of Refractory in Reheat Furnaces
  Greg Odenthal, International Technical Ceramics LLC (ITC)
  This presentation provides attendees with an understanding of the role and importance of refractories in a reheat furnace and how they relate to fuel consumption and energy loss as well as product quality.

- Energy Efficiency and Economics

- Steel Mill Combustion and Thermal Systems

Afternoon Sessions (1:30 p.m.)

- Plant Tour of Bloom Engineering Co. Inc.

- Roundtable Discussion

Adjourn (5 p.m.)

## THURSDAY, 29 OCTOBER

Morning Sessions (8:30 a.m.)

- CFD Application in the Steel Industry 1: Fundamentals and Applications, Blast Furnace, EAF and Reheat Furnace
  Chenn Zhou, Center for Innovation Through Visualization and Simulation, Purdue University Northwest
  The Steel Manufacturing Simulation and Visualization Consortium (SMSVC) develops and implements technical solutions through the integration of advanced computer simulation and visualization technologies for the value chain of U.S. steel manufacturing. Energy efficiency is a major focus in SMSVC research. To-date research outcomes include improved energy efficiencies and identification of energy reduction opportunities.

- CFD Application in the Steel Industry 2: Oxy-Fuel Combustion Applications
  Xiaoyi He, Air Products and Chemicals Inc.
  Computational fluid dynamics modeling plays an important role in improving efficiency and reducing operational risks from the oxygen-fuel combustion. The presentation will discuss the best practice and previous experience by Air Products in this field.

- Combustion/Thermal Troubleshooting Case Studies

Conference Adjourn (1 p.m.)


## ABOUT THE PROGRAM

The modern production of steel has evolved over many centuries, with many technological improvements during the last 25 years. The making, shaping and treating of steel are critical to product design, application, cost and performance. It is essential that employees involved in producing iron and steel, operating rolling mills, supplying equipment and materials to the steel industry, designing products, engineering, sales, and construction have an understanding of what steel is, how it is produced, and the effects of making, shaping and treatment on the final performance of steel products. This course provides essential knowledge to those who do not have a technical background in metallurgical engineering, rolling or quality-added downstream processing but have a need to understand more about the technical aspects of steel manufacturing, properties and applications.

## WHO SHOULD ATTEND

Iron and steel industry production workers and supervisors, equipment and materials suppliers to the steel industry, steel marketing and sales personnel, machine shop personnel, quality control technicians and supervisors, and component designers and engineers.

## REGISTRATION INCLUDES

Wednesday and Thursday breakfast and lunch; Wednesday reception; plant tour with bus transportation; choice of *The Making, Shaping and Treating of Steel*® CD-ROMs, which include one of the following volumes from the 11th edition: *Ironmaking, Steelmaking/Refining, Casting, Flat Products* and *Long Products;* and a course workbook or flash drive including presentations.

## INSTRUCTORS

Frank Fonner, director of quality and metallurgical engineering, NLMK USA, Farrell, Pa., USA

Bryan Webler, assistant professor, Materials Science and Engineering Department, Carnegie Mellon University, Pittsburgh, Pa., USA

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## THE MAKING, SHAPING AND TREATING OF STEEL: 101

## WEDNESDAY, 4 NOVEMBER

Morning Sessions (8 a.m.)

- Overview of the Making, Shaping and Treating of Steel and History of the Industry
  The first session provides an overview of the technologies used to produce steel today and the evolution of world steel production. The general chemistry of steel is introduced to help illuminate the principles of iron- and steelmaking. This session ends with a brief history of metals production and an introduction to early iron- and steelmaking processes.

- Ironmaking and Steelmaking
  This session explains the techniques used to produce iron and steel from raw materials, including ores and recycled materials. Processes reviewed include the blast furnace, direct reduction, ferrous scrap production, basic oxygen steelmaking and electric furnace steelmaking. Important gas, slag and metal reactions will be explained, as well as the impacts of the processes on energy and the environment. The effects of the different processing techniques will be explained, and future iron- and steelmaking developments will be explored.

- Secondary Metallurgy
  Basic, acid, and neutral slags and refractories will be introduced, along with reasons for using each. The interaction of refractories and slags with metal will be explored, including methods of reducing refractory wear and quality improvements. The use of ladle metallurgy treatment and furnaces will be explained. The principles behind other secondary steelmaking techniques will be explained, including degassers and argon oxygen decarburization steelmaking for the production of high-quality steels such as ultralow-carbon and stainless steels. Inclusion formation, modification and removal will be discussed.

Afternoon Sessions (Noon)

- Lunch and Depart for Plant Tour (Noon)

- Reception (5 p.m.)

Adjourn (6 p.m.)

## THURSDAY, 5 NOVEMBER

Morning Sessions (8 a.m.)

- Solidification Fundamentals and Batch Casting
  The importance of solidification on final product quality will be discussed. The effects of tundish and mold metallurgy on product quality will be explained, along with casting defect causes and methods of prevention.

- Continuous Casting of Steel
  The history and evolution of continuous casting processes from billets, blooms, and slabs to near-net-shape processes for thin slabs, strip, beam blanks and wire will be reviewed.

- Introduction — Hot-Rolled As-Rolled End Products and Product Applications
  The various end products of steel manufacturing will be introduced. The requirements and methods to produce these products will be reviewed.

Afternoon Sessions (1 p.m.)

- Hot Rolling — Reheat, Hot Rolling, Incoming and Hot-Rolled Defects
  This section will provide an introduction to the theory of rolling and the effects of deformation processing on product quality and properties. The importance of the reheating process and how it affects subsequent rolling and quality will be discussed. Billets and blooms will also be reviewed.

- Steel — Types, Mechanical Properties, Tests and Consistency
  Characteristics, applications and mechanical properties of steel alloys and grades will be explored. The effects of different alloying elements on steel manufacturing and final properties will be explained. An introduction of the methods of testing the properties of steel — including tensile, toughness and fatigue testing — will lead into discussions of the importance of melting, casting, rolling and forming on the final mechanical properties. The importance of selecting alloys and processing routes for specific engineering applications to achieve desired properties will be explained.

- Downstream Processing — Cold Rolling, Annealing and Coating
  Steel finishing techniques, including heat treating and coating, will be reviewed. Basic steel heat treatment concepts of quenching, tempering, case hardening and in-process annealing will be introduced, along with the effects they have on steel microstructure and properties. Surface coating techniques, including galvanizing and other coatings, will be discussed.

Conference Adjourn (5 p.m.) ✦

# David Wedmore

## 38-Year Life Member

*Wedmore and his family.*

**David Wedmore** began his steel industry career with Flo-Con Systems in 1980 as an account manager mainly supporting field operations in Western Pennsylvania for companies such as Washington Steel, J&L Aliquippa, AK Steel – Butler Works (ARMCO) and Allegheny Ludlum. In 1990, Vesuvius acquired Flo-Con Systems and Wedmore assumed account responsibility for customers such as Weirton Steel; U. S. Steel – Mon Valley Works, Edgar Thomson Works; and J&L Specialty. In the mid-1990s, Wedmore was promoted to Pittsburgh district manager. In the early 2000s, when Vesuvius' steel sales division branched out into two main business units, Flow Control and Advanced Refractories, Wedmore stayed on with the Flow Control Business Unit. In 2008, he was promoted to regional sales manager – East Region Flow Control.

**Tell me a bit about your background. How did you get involved in the steel industry?**
After graduating college in 1978 from Indiana University of Pennsylvania with a degree in business and finance, I ended up as a collection manager for a finance company. I quickly realized that this was not something I wanted to continue to do for the long term. As luck would have it, in 1980 one of my good friends, Jack Petrick, was recently employed by Flo-Con Systems. In the summer of 1980, at Jack's wedding, I met Jack's boss Jim Waddell. One thing led to another and by September 1980 I was a new employee of Flo-Con Systems. This was in the early days of the blossoming continuous casting technology, which helped to drive the need for a better ladle pouring system. Flo-Con Systems' main product was ladle slidegate systems, and in those first years I helped support the many ladle gate conversions that were underway across the steel industry. Although the work was demanding, it was rewarding

*JSW startup (right to left): D.J. Morris, Angelo Bianco, Wedmore, Alex Allen and Craig Macdonald, all working for Vesuvius as part of the startup team.*

*AIST golf outing (left to right): Angelo Bianco, Matt Widders (TimkenSteel), Brett Ferrara and Wedmore.*

and provided a sense of adventure unlike anything I had ever experienced. I quickly fell in love with our products, the steel industry and the rewarding challenges it provided.

### Was there a person or a group of people who served as a mentor to you in the early stages of your career?

In addition to Jack Petrick and Jim Waddell, my first boss was Jim Engel. He had a larger-than-life personality (as it seemed many people in the steel industry possessed). He helped instill in me that hard work and perseverance will pay off. We worked hard and played hard, and managed to have fun along the way. We used to wear the famous Pittsburgh Steelers coach Chuck Knoll's saying on our hard hats: "Whatever It Takes." During my district manager years, I reported to Lou Sebastian, who was a big influence in helping to shape my business sense.

From the customer side, many of my early contacts helped shape my career and I thank them all for their support. Notables include: Joe Kusic from Washington Steel; Hoopie Majors from J&L Aliquippa; Ralph Deabrunzzo from AK Steel – Butler

*Wedmore's district manager team (left to right): Brett Ferrara, Angelo Bianco, Don Dean, Wedmore and Dennis Brady.*

Works; John Nieman from Weirton Steel; Kevin Smith from Allegheny and AK Steel – Butler Works; Ed DiCiccio from J&L Specialty; and Bob Trunzo from U. S. Steel – Mon Valley Works, Edgar Thomson Plant.

*Wedmore and his wife Tara on a ski trip to Big Sky, Mont., USA, March 2020.*

**When did you first hear about ISS/AISE and how?**

Early in my career I joined the Iron & Steel Society (ISS) and heard through my industry contacts what a valuable networking organization it was. I was encouraged to join by my management and over the years participated in many of the local chapter meetings, annual technical conference and exhibition, and, of course, the Pittsburgh District golf outings.

**What was your first level of involvement in the organization? Do you remember your first event?**

My first event was the ISS Pittsburgh District's annual golf event, which had a tremendous turnout every year. Here I was, a young lad, and I'm thinking "How great — I get to be away from the mill, be with friends and colleagues, and call it a workday." I was sold. Of course, the golf was great, but it was much more than that. To see these people away from the daily grind in a relaxed setting and get a chance to discuss business (or not) was an invaluable experience.

**How has AIST membership benefited you in your career?**

AIST is not only a great organization for networking with like-minded people, it promotes the sharing of a wealth of industry information via the monthly *Iron & Steel Technology* magazine, the Technology Training Conferences, and AISTech. The information you can pick up from this organization is invaluable to one's career development.

**How have you seen the industry change since you started? Are there any new developments that particularly excite you?**

My career has centered in the northeast U.S., and I have seen both highs and lows of the industry cycles. My geographical area has lost many iconic steelmaking centers over the years. While those closures were difficult, I could see firsthand how the survivors came out of these cycles stronger and better able to handle the challenges of the future. The transformation of the industry from one requiring hard labor to a high-tech industry has been a fascinating experience.

**At AIST, we're always looking to inspire the next generation of steelmakers. What advice would you give to young professionals who are just coming into the steel industry?**

I always encourage our young new hires to join AIST and participate in local Member Chapter events or join one of the Technology Committees for the reasons I mentioned. I would also encourage anyone interested in the steel industry to try visit a steelmaking shop and witness it firsthand. It is hard to appreciate the process without seeing it — the sheer scale of these operations is mindboggling. ✦

# NOTES FROM A LEADER

## Jacob Lewis
metallurgist

NUCOR STEEL TUSCALOOSA, INC.

One of my most vivid memories from childhood was picking up my Dad's copy of *Iron & Steel Technology* and being fascinated with the rolling mill that was on the front cover. The huge mill stands and the glowing red bar sitting on the table had me instantly hooked as a kid. Fast forward a decade, and I was so excited to start my first day at Nucor Steel Tuscaloosa Inc. After orientation, safety training and meeting my teammates, one of the first things I was asked was if I was interested in receiving *Iron & Steel Technology* each month. Remembering my younger years, I said yes. I was beginning to truly understand how valuable this publication and AIST would be for me and my career.

Six months later I sat in my first AIST training course, The Making, Shaping and Treating of Steel: 101. I was blown away with the amount of knowledge I gained in that three-day course, and quickly wanted to expand my knowledge further, so I attended Cold Rolling Fundamentals. Both courses helped me to better understand the steel industry, my job, and the new technological advances of both steel and the equipment needed to produce that steel. Moreover, I also got the chance to network with suppliers and other producers, giving me contacts I could reach out to when I hit a wall in a project. Over the six years I've been at Nucor Tuscaloosa, I've also attended the Hot Rolling Fundamentals course, attended AISTech, presented at a Plate Steel Symposium, and joined the Plate Rolling Technology Committee. These learning and networking experiences have been immensely important to my development early in my career.

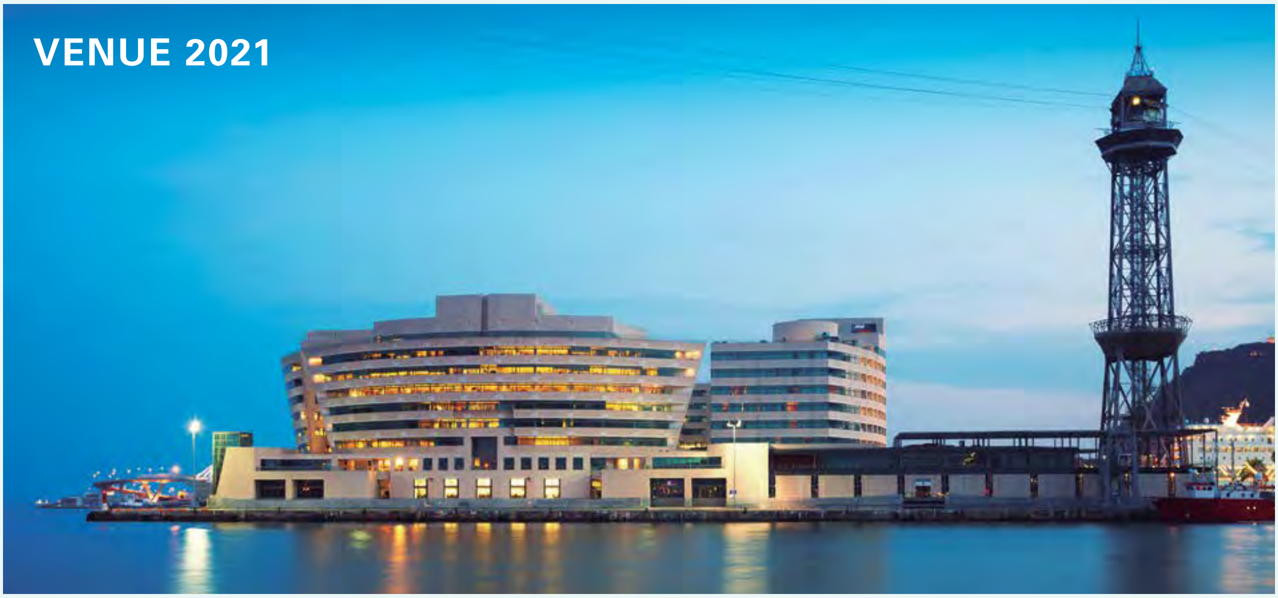
Another great experience has been my involvement with the Birmingham Member Chapter. Before I moved to Alabama, I had no idea the amount of iron and steel history that was present in the state. The amount of old blast furnaces that are still scattered throughout the state today are truly amazing (and Sloss Furnaces in Birmingham is worth a tour if you are ever in the area). Around the spring of 2017, I was asked to fill in for one of my co-workers as a scholarship chair for the Birmingham chapter. During my first meeting, we discovered that several of the previous leaders had moved out of the region, and all three leadership positions were open. I ended up being elected secretary/treasurer, as well as scholarship chair for the chapter, and my involvement since has only grown. Thanks to our chapter meetings, I've gotten to meet several people from Birmingham and the surrounding areas and have called on them frequently for help and guidance when encountering difficulties. I also was able to help plan a joint meeting with the Southwest Member Chapter, again expanding my contacts in the industry. I was very honored to be named Birmingham Member Chapter chair in 2019, and to continue the work of the past leaders of the Birmingham Chapter.

One of my favorite aspects of being an officer of the Birmingham Member Chapter is awarding scholarships to several bright and gifted students, many of whom I've since met at our chapter meetings. These students will be a huge asset for the industry moving forward. Through its Member Chapters, AIST and the AIST Foundation have done a great job of recruiting young students and professionals to our industry. The push to get even more young professionals involved in AIST will be an even greater benefit to those young people entering the steel industry now. The amount of knowledge you can quickly learn from any AIST event is extremely beneficial, and I would urge any student or young professional to take advantage of these opportunities. The networking alone at these events will help with your development and advancement. ✦

**AIST MEMBER CHAPTERS**

Get involved with your local Member Chapter! Visit AIST.org or contact Jill Liberto at +1.724.814.3046 or jliberto@aist.org.

## VENUE 2021



For the first time, the CHS² conference will be held in Barcelona, Spain, 31 May–3 June 2021, at World Trade Center Barcelona.

CHS² 2021 will be organized by Eurecat, the Technology Centre of Catalonia and Luleå University of Technology, in cooperation with the Association for Iron & Steel Technology (AIST).

**31 May 2021:** Reception and pre-registration

**1 June 2021:** Registration and conference

**2–3 June 2021:** Conference

**WORLD TRADE CENTER**
**Moll de Barcelona s/n, Barcelona, Spain**
**www.wtcbarcelona.com/en**

## CONFERENCE TOPICS

### Material

- High-performance steels
- Lightweight and high-performance materials such as aluminum alloys, magnesium alloys, titanium alloys, superalloys, composite materials, etc.
- Mixed material processes and multi-material solutions
- Tool materials
- Microstructure – properties relationship
- Surface engineering and coatings
- Additive manufacturing solutions

### Modeling and Simulation

- Process modeling
- Microstructure
- Heat transfer
- Thermomechanical properties
- Friction and wear
- Component properties
- Deformation, fracture and fatigue

### Process Design

- Tool systems
- Heating and cooling strategies
- Automation and control
- Process monitoring
- Artificial intelligence and machine learning

### Products

- Lightweight and high-performance components for transport sector
- Solutions for e-mobility needs
- Product innovations and optimization
- New products for new markets
- Tailored material properties
- Cutting and joining technologies
- Fatigue, fracture and crash performance
- Circular economy and life cycle assessment
- Eco-design

## CALL FOR PAPERS

All contributions on the theme of the conference are welcome. Prospective authors are invited to submit their abstracts by uploading these to the conference paper submission system (see instructions below). The full papers will be reviewed by the members of the scientific advisory board and, if accepted, will be published in the conference proceedings.

The organizing committee encourages high-scientific-quality conference papers to be published in international journals after the conference.

For submission of abstracts, please register with the conference paper submission system and upload your abstract in accordance with the abstract submission guidelines:
**www.chs2.eu**

## ABSTRACT SUBMISSION GUIDELINES

**Abstract text:**
maximum 400 words

**Language:**
English

**The abstract submission includes:**

- title of paper
- presenting author
- co-authors
- affiliations
- abstract including keywords and references

## IMPORTANT DATES

**Abstract submission:**
15 October 2020

**Full paper submission:**
8 February 2021

**Revised paper submission:**
5 April 2021

**Conference:**
31 May–3 June 2021

## ORGANIZING COMMITTEE

- **Prof. Daniel Casellas**
  Eurecat, Technology Centre of Catalonia, ESP/Luleå University of Technology, SWE
- **Prof. Mats Oldenburg**
  Luleå University of Technology, SWE
- **Dr. Jens Hardell**
  Luleå University of Technology, SWE
- **Brian Bliss**
  Association for Iron & Steel Technology (AIST), USA

## CONFERENCE SECRETARY

**Ms. Ana Vázquez**

Eurecat, Technology Centre of Catalonia
Bilbao, 72 Building A
08005 Barcelona – Spain

Tel.: + 34 932 381 400
Email: chs2@eurecat.org

**Updated information can be found on the conference homepage www.chs2.eu**

## ORGANIZED BY

**Eurecat, Technology Centre of Catalonia**
Barcelona, Spain

eurecat

**Luleå University of Technology**
Luleå, Sweden

LULEÅ UNIVERSITY OF TECHNOLOGY

# Get Involved With Your Local Member Chapter

## Global Collaboration

A globally diversified membership is key to fulfilling the AIST mission and vision. Our programs enable professionals in the iron and steel industry and related academia from more than 70 countries to gather in 21 regions, recognized as local Member Chapters.

AIST Member Chapters meet to exchange ideas and provide opportunities for networking among peers in your local area. Activities include technical keynote presentations, roundtable discussions, plant tours, social activities, product fairs and special programs to engage the next generation.

"Whether you are a young engineer learning the ways of the industry or a longtime professional passing on your knowledge and insight, involvement in AIST can benefit not only the individual but the iron and steel industry as a whole."

**Clay Piper,**
senior project engineer, DMM Technical Services LLC

# Local Member Chapters

## Asia
- India
- Korea

## Australia
- Australia

## Europe
- European

## North America
- Birmingham
- Detroit
- Globe-Trotters*
- Mexico
- Midwest
- Northeastern Ohio
- Northern
- Northern Pacific
- Ohio Valley
- Philadelphia
- Pittsburgh
- Southeast
- Southern California
- Southwest
- St. Louis

## South America
- Argentina
- Brazil

## Provisional
- Middle East and North Africa (MENA)

*The Globe-Trotters Member Chapter is a traveling group with events in various locations throughout the United States.

Visit AIST.org to learn more about AIST Member Chapters.

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# 2020 EDITORIAL CALENDAR

## October

Process Metallurgy & Product Applications

| Bonus Feature: | Ad Closing | Material Due Date |
|---|---|---|
| MS&T20 Program | 18 August 2020 | 24 August 2020 |

### Feature Articles

**Effect of Vanadium and Aluminum Grain Refining Treatment on Steel Machinability**
Missouri University of Science and Technology, Gerdau Special Steel North America, MetalTek International, and University of Science and Technology Beijing

**Effect of Liquid Metal Embrittlement on Mechanical Behavior of Advanced High-Strength Steel Spot Welds at Ambient and Low Temperatures**
Colorado School of Mines

**Effect of Plasma Heating on the Molten Steel in Tundish**
University of Science and Technology Beijing, Beijing Key Laboratory of Special Melting and Preparation of High-End Metal Materials, and Wuhu Xinxing Ductile Iron Pipes Co. Ltd.

**Microstructural Evolution of Two Automotive Steels Induced by Warm Forging and Subcritical Annealing**
Universidad de Ingenieria y Tecnologia, Universidade Federal de Santa Catarina, Universidad Central and Universidad Nacional de Colombia

**Metallurgical Strategy for Optimized Production of QT High-Strength and Abrasion-Resistant Plate Steels**
DGS Metallurgical Solutions Inc.

**Investigation on the Coating Adhesion of Galvanized AHSS Treated by Oxidation-Reduction Process**
Baosteel and Pan Asia Technical Automotive Center Co. Ltd.

**Fraudulent N-95 *(Safety First)***
Steel Dynamics Inc.

**Inclusion Classification by Computer Vision and Machine Learning *(Digital Transformations)***
Carnegie Mellon University and RJ Lee Group Inc.

| Month and Feature Topic | | Ad Closing / Material Due Date |
|---|---|---|
| **November** | Hot Flat Product Rolling, Rolls, Safety & Health | 23 September 2020<br>29 September 2020 |
| **December** | Process Control & Automation | 21 October 2020<br>27 October 2020 |
| **January 2021** | Electric Steelmaking | 16 November 2020<br>20 November 2020 |
| **February 2021** | Cold Sheet Rolling, Processing, Coating & Finishing | 15 December 2020<br>21 December 2020 |

To advertise, contact the AIST sales team at **sales@AIST.org** or call **+1.724.814.3000, ext. 2.**

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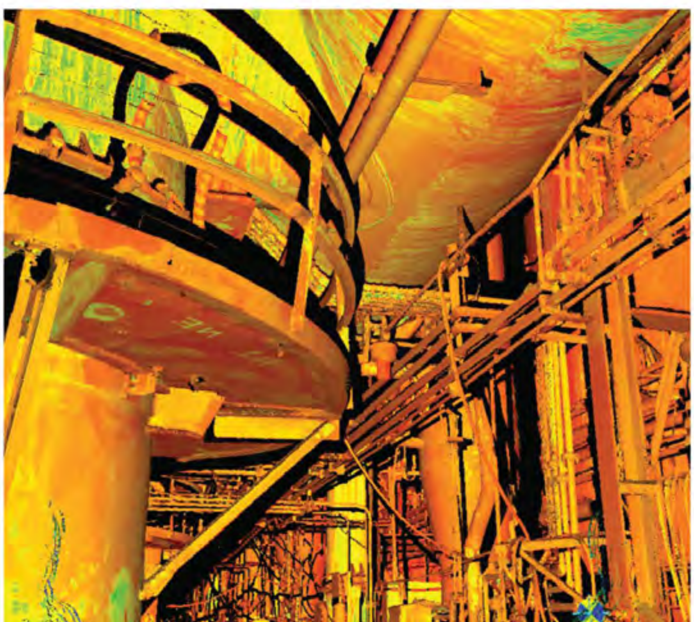
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- 3D Precision Laser Tracking
- 3D Modeling
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- Maintenance As-builts and Adjustments
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New Products & Resources is a free service featuring news of recent product and equipment developments, brochures, catalogs, websites, etc., relevant to the steel industry. To submit material for consideration, please email a press release (and high-resolution photo, if applicable) to jemling@aist.org.

## Explosion-proof VFD phase converter for hazardous environments

Larson Electronics, a manufacturer of industrial lighting equipment and accessories, announced the release of an explosion-proof 3-phase input, 3-phase output, 3-wire configuration variable frequency drive (VFD) designed for improving AC motor performance in hazardous locations. This device is a fan-cooled unit featuring 3-phase 480-V AC input/output voltage.

The EXP-VFD-3P-480-20HP-33A-DCM explosion-proof VFD phase converter is rated for use in U.S. Occupational Safety and Health Administration (OSHA) Classes I and II, Divisions 1 and 2 hazardous locations. This device offers accurate AC motor control in industrial environments. This 15-kw device is compatible with 3-phase input and 3-phase output of 480-V AC (430–525 V) and provides an output current of 33 amps. This unit offers an operating frequency range of 0–400 Hz.

Larson Electronics' VFD phase converter is a 20-hp unit that has a volts-per-hertz (V/F) control mode and sensorless vector control mode. This unit is designed for indoor applications with an operating temperature range of –10°C to 40°C. This unit is also ideal for outdoor applications and is suitable for speed control of AC motors, industrial machines and more.

Contact: Larson Electronics LLC
9419 E. U.S. Hwy. 175
Kemp, TX 75143 USA
Toll-Free Phone: +1.800.369.6671
Phone: +1.903.270.1187
Fax: +1.903.498.3364
sales@larsonelectronics.com
www.larsonelectronics.com

## New standards builder tool saves project creation time

The new ProposalWorks Standards Builder from Rockwell Automation is an application designed to assist end users with generating, customizing and maintaining their control standards. Engineers can document project standards, track revisions and more to help establish consistency from project design through procurement and commissioning. Although Standards Builder is its own capability, users launch the application via the Rockwell Automation ProposalWorks tool.

Users can output detailed specification documents and a standards bill of materials that can be uploaded into ProposalWorks. They can share this with others, including suppliers, to help product design and selection.

Control standards creation and maintenance can be a manual, time-consuming process. Typical information included in a control standard can contain electrical code, product line and reference architecture content. Users can be unaware of changes in life cycle status and product obsolescence after a control standard is published. With Standards Builder, users can spend less time maintaining control standards or specifications and also create more detailed content that is easier to maintain than in a static document.

In addition, users can achieve a higher standardization of systems, resulting in fewer spare parts, less training and more reliable designs. They can easily add a wider range of product lines or products to their standards or specs with minimal effort. This can provide improved product availability and better alignment with suppliers during design/build.

Contact: Rockwell Automation Inc.
1201 S. Second St.
Milwaukee, WI 53204 USA
Phone: +1.414.382.2000
www.rockwellautomation.com ✦

## Marketplace


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## AUGUST 2020

5 AIST **Technology Training**
- **Machine Learning Applications for Process Control and Optimization in Steelmaking**
  Webinar, 10–11 a.m. EDT
  Phone: +1.724.814.3000
  conferences@aist.org or AIST.org

12 AIST **Technology Training**
- **Integrated Production Management and Quality in the Age of Industry 4.0**
  Webinar, 10–11 a.m. EDT
  Phone: +1.724.814.3000
  conferences@aist.org or AIST.org

19 AIST **Technology Training**
- **Digitalization and the Double-Edged Sword: Transparency**
  Webinar, 10–11 a.m. EDT
  Phone: +1.724.814.3000
  conferences@aist.org or AIST.org

20 AIST **Member Chapter Event**
- **Midwest**
  Golf outing, White Hawk Country Club, Crown Point, Ind., USA

## SEPTEMBER 2020

8 AIST **Member Chapter Event**
- **St. Louis**
  47th annual golf outing, Spencer T. Olin Golf Course, Alton, Ill., USA

21 AIST **Member Chapter Event**
- **Detroit**
  Annual golf outing, Walnut Creek Country Club, South Lyon, Mich., USA

27–1 Oct AIST **Technology Training**
- **Sheet Processing and Finishing Lines — A Practical Training Seminar**
  Sheraton Indianapolis City Centre Hotel, Indianapolis, Ind., USA
  Phone: +1.724.814.3000, Fax: +1.724.814.3001,
  conferences@aist.org or AIST.org

29–1 Oct AIST **Technology Training**
- **27th AIST Crane Symposium**
  Omni William Penn Hotel, Pittsburgh, Pa., USA
  Phone: +1.724.814.3000, Fax: +1.724.814.3001,
  conferences@aist.org or AIST.org

29–1 Oct **23rd IAS Steel Conference and EXPO IAS 2020**
Instituto Argentino de Siderurgia, Rosario, SF, Argentina
Phone: +54.0336.4462989 or +54.0336.4461795, ext. 19,
conferencia2020@siderurgia.org.ar or
www.siderurgia.org.ar/conf20

## OCTOBER 2020

2 AIST **Member Chapter Event**
- **Midwest**
  13th annual high school engineering seminar, Purdue University Northwest, Hammond, Ind., USA

4–8 **MS&T20 — The Materials Science & Technology Conference and Exhibition**
David L. Lawrence Convention Center,
Pittsburgh, Pa., USA
Sponsored by ACerS; AIST; and The Minerals, Metals & Materials Society (TMS).
Phone: +1.724.814.3000, Fax: +1.724.814.3001,
conferences@aist.org or AIST.org

**COVID-19:** The health and safety of our industry is a shared responsibility and one that we take seriously. As of press time, AIST is actively monitoring the COVID-19 crisis as it may necessitate the postponement or cancellation of steel calendar events. Please visit AIST.org for updates or contact us at memberservices@aist.org.

6–8 AIST **Technology Training**
- **Secondary Steelmaking Refractories — A Practical Training Seminar**
  Holiday Inn Nashville Vanderbilt, Nashville, Tenn., USA
  Phone: +1.724.814.3000, Fax: +1.724.814.3001,
  conferences@aist.org or AIST.org

13–15 AIST **Technology Training**
- **Continuous Casting — A Practical Training Seminar**
  Holiday Inn Cleveland South – Independence, Independence, Ohio, USA
  Phone: +1.724.814.3000, Fax: +1.724.814.3001,
  conferences@aist.org or AIST.org

13–15 AIST **Member Chapter Event**
- **European**
  Virtual European Steel Forum

19–21 AIST **Technology Training**
- **Environmental Solutions: Meeting EPA Air Emission Requirements**
  TBD, Dearborn, Mich., USA
  Phone: +1.724.814.3000, Fax: +1.724.814.3001,
  conferences@aist.org or AIST.org

21–23 **ECCC 2020 — 10th European Conference on Continuous Casting**
Nicolaus Hotel, Bari (BA), Italy
Sponsored by AIM, the Italian Association for Metallurgy.
aim@aimnet.it or www.aimnet.it

27–29 AIST **Technology Training**
- **Steel Mill Combustion and Thermal Systems**
  AIST Headquarters, Warrendale, Pa., USA
  Phone: +1.724.814.3000, Fax: +1.724.814.3001,
  conferences@aist.org or AIST.org

28–30 **IRONMASTERS 2020**
Schönbrunn Palace, Vienna, Austria
Sponsored by ASMET.
www.ironmasters2020.org

## NOVEMBER 2020

4–5 AIST **Technology Training**
- **The Making, Shaping and Treating of Steel: 101**
  AIST Headquarters, Warrendale, Pa., USA
  Phone: +1.724.814.3000, Fax: +1.724.814.3001,
  conferences@aist.org or AIST.org

7 AIST **Member Chapter Event**
- **Southern California**
  Dinner dance, Omni Rancho Las Palmas Resort & Spa, Rancho Mirage, Calif., USA

8–10 AIST **Leadership Conference (invitation only)**
Omni Rancho Las Palmas Resort & Spa, Rancho Mirage, Calif., USA
Phone: +1.724.814.3000, Fax: +1.724.814.3001,
conferences@aist.org or AIST.org

8–10 AIST **Member Chapter Event**
- **Northern Pacific and Southern California**
  Western Conference, Omni Rancho Las Palmas Resort & Spa, Rancho Mirage, Calif., USA

8–12 **Galvatech 2020**
Schloss Schonbrunn, Apothekertrakt, Vienna, Austria
Sponsored by ASMET (The Austrian Society for Metallurgy and Materials).
www.galvatech2020.org

11–12 **MetCoke World Summit 2020**
TBD, Pittsburgh, Pa., USA
Sponsored by Smithers.
www.metcokemarkets.com

30–2 Dec AIST **Member Chapter Event**
- **Mexico**
  CONAC 2020, Cintermex, Monterrey, N.L., Mexico

## FEBRUARY 2021

1–5 AIST **Technology Training**
- **Modern Electric Furnace Steelmaking — A Practical Training Seminar**
  Tennessee, USA
  Phone: +1.724.814.3000, Fax: +1.724.814.3001,
  conferences@aist.org or AIST.org

9–11 AIST **Technology Training**
- **Long Products Rolling – A Practical Training Seminar**
  Sheraton Gunter Hotel, San Antonio, Texas, USA
  Phone: +1.724.814.3000, Fax: +1.724.814.3001,
  conferences@aist.org or AIST.org

24–26 AIST **Technology Training**
- **Maintenance Solutions: Fundamentals and New Frontiers**
  Embassy Suites Riverwalk, San Antonio, Texas, USA
  Phone: +1.724.814.3000, Fax: +1.724.814.3001,
  conferences@aist.org or AIST.org

## MARCH 2021

15–17 AIST **Technology Training**
- **Digital Transformation Forum for the Steel Industry**
  Omni William Penn Hotel, Pittsburgh, Pa., USA
  Phone: +1.724.814.3000, Fax: +1.724.814.3001,
  conferences@aist.org or AIST.org

## MAY 2021

3–6 **AISTech2021 — The Iron & Steel Technology Conference and Exposition**
Music City Center, Nashville, Tenn., USA
Organized by AIST.
Phone: +1.724.814.3000, Fax: +1.724.814.3001,
conferences@aist.org or AIST.org

## JUNE 2021

23–25 **ROLLS6 2021**
One Great George Street, London, U.K.
Sponsored by IOM3, The Institute of Materials, Minerals and Mining.
conferences@iom3.org or www.rolls6.org/485897

23–25 **High-Tech Die Casting International Conference**
Vicenza, Italy
Sponsored by AIM, the Italian Association for Metallurgy.
info@aimnet.it or www.aimnet.it/htdc2020.htm

## JULY 2021

5–7 **TMP2021 — The 6th International Conference on ThermoMechanical Processing**
Shenyang, China
Sponsored by The Chinese Society for Metals.
tmp2020.medmeeting.org/en

## AUGUST 2021

28–31 AIST **Member Chapter Event**
- **Globe-Trotters**
  Annual meeting, Omni Amelia Island Plantation and Resort, Fernandina Beach, Fla., USA

## SEPTEMBER 2021

28–31 AIST **Member Chapter Event**
- **Southeast**
  Annual meeting, Marina Inn at Grande Dunes, Myrtle Beach, S.C., USA ✦

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## Where's the Hypocycloid?

Each month a hypocycloid (✦) is "hidden" on the cover of *Iron & Steel Technology*. While its size and color may vary, its shape is maintained. Every month, *Iron & Steel Technology* uses this space at the end of "Steel Calendar" to point out where the hypocycloid was hidden on the previous issue's cover. When you find the hypocycloid, post it to AIST's Facebook page. Challenge yourself to find it before looking on the page for the answer.

AIST
ASSOCIATION FOR IRON & STEEL TECHNOLOGY
186 Thorn Hill Road
Warrendale, PA 15086-7528 USA
+1.724.814.3000
Fax +1.724.814.3001
AIST.org