

Tenova is a worldwide supplier of advanced technologies, products and engineering services for the iron & steel and mining industries providing innovative integrated solutions. By combining process automation and metallurgical know-how enhanced value is delivered to the customer. Tenova is committed to develop technology in the areas that most impact the future of the industries it serves: quality of the products delivered by the customers, energy savings and benefits including reductions in greenhouse gas emissions.

Goodfellow EFSOP Holistic Optimization™ is the world's most reliable real-time off-gas process control tool for the EAF. It continuously measures and analyzes fourth-hole off-gas chemistry to provide real-time knowledge of the melting process and furnace conditions. Together with other process data it dynamically controls and improves the efficiency of EAF steelmaking through the optimization of chemical and electrical energy.

### PROVEN EFSOP® BENEFITS

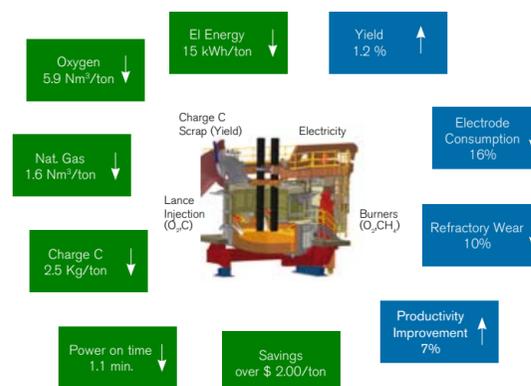
- Typical payback less than one year
- Average historical savings of over US\$ 2.00/ton by present EFSOP® customers
- Up to 20-25 kWh/ton lower electrical energy consumption
- Up to 4-5% shorter power-on-time and increased productivity
- Guaranteed probe life of one year, with typical life up to 3 years
- Less than one hour/week maintenance with no specialized personnel required
- Enhanced melt shop safety with proven Water Detection Technology
- Improved process control provides greater operating consistency and flexibility
- More effective post combustion optimization reduces energy consumption & greenhouse gas emissions (-18%)
- Robust equipment with more than 12 years of proven successes in steel plant environments
- Over 60 installations worldwide
- More than 10 international awards recognizing EFSOP® technology

### OVERALL EAF BENEFITS FROM EFSOP®

|  |  |
|--|--|
| Increased Productivity and Yield                               | Lower Conversion Costs                           |
| Improved Process Efficiency & Consistency                      | Lower Chemical and Electrical Energy Consumption |
| Reduced Emissions & Dependence on Non-Renewable Energy Sources | Enhanced Baghouse & Furnace Safety               |
| Long term Sustainable Benefits in Changing Market Conditions   | Improved Total Business Performance              |

### EFSOP® OPERATING RESULTS (/TON OF GOOD BILLET)

Actual results shown are from a North American installation.



■ Parameters Directly Controlled by EFSOP®  
 ■ Variables Influenced by Parameters Directly Controlled by EFSOP®

### AVERAGE EFSOP® OPERATING RESULTS IN GLOBAL MARKETS

Performance Parameter Improvement evaluated over 40 Running EFSOP installed on EAF.

| % Decrease (Average)                    |            |
|---|------------|
| Electrical Consumption                  | 3,3        |
| Oxygen Consumption                      | 1,0        |
| Natural Gas Consumption                 | 14,0       |
| Charge Carbon Consumption               | 28,3       |
| Injected Carbon Consumption             | 9,5        |
| Power ON Time                           | 2,9        |
| % Increase (Average)                    |            |
| Productivity                            | 5,2        |
| Yield                                   | 0,7        |
| <b>TOTAL AVERAGE SAVINGS (US\$/ton)</b> | <b>2,2</b> |



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## Goodfellow EFSOP® Technology

Helping EAF producers improve total business performance through proven technology

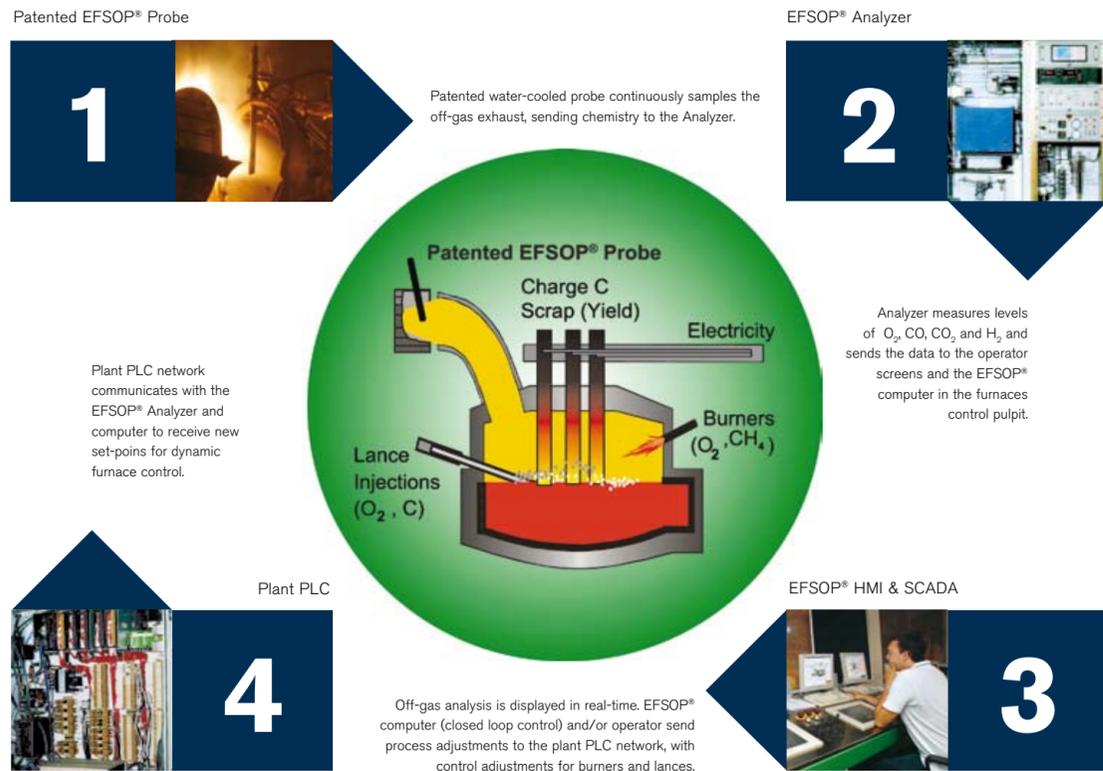
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TENOVA is a worldwide supplier of advanced technologies, products and engineering services for the iron & steel and mining industries.

## EFSOP® THE CORNERSTONE OF THE HIGH PERFORMANCE EAF



## REAL-TIME OFF-GAS ANALYSIS FOR GREATER EAF CONTROL

Goodfellow EFSOP® is a real-time off-gas based process control system for EAFs. Measuring and analyzing CO, CO<sub>2</sub>, O<sub>2</sub>, and H<sub>2</sub> continuously at the fourth hole, EFSOP® uses real-time off-gas chemistry to optimize chemical energy and post-combustion under closed-loop control conditions.

In addition, off-gas chemistry along with process variables are used to optimize electrical energy, carbon & lime usage, slag formation and control and fume system heat load. Goodfellow EFSOP® has provided steelmakers around the world with the most reliable real-time off-gas based process control system for EAF. Through continuous upgrading and state of the art technology, EFSOP® is the process control tool of choice for over 60 cost conscious, high productivity melt shops. Low maintenance, fast payback and over 2 million heats analyzed has resulted in significant reductions in overall EAF conversion costs, including lower kWh and other sources of energy (ie. charge/injection carbon and natural gas)

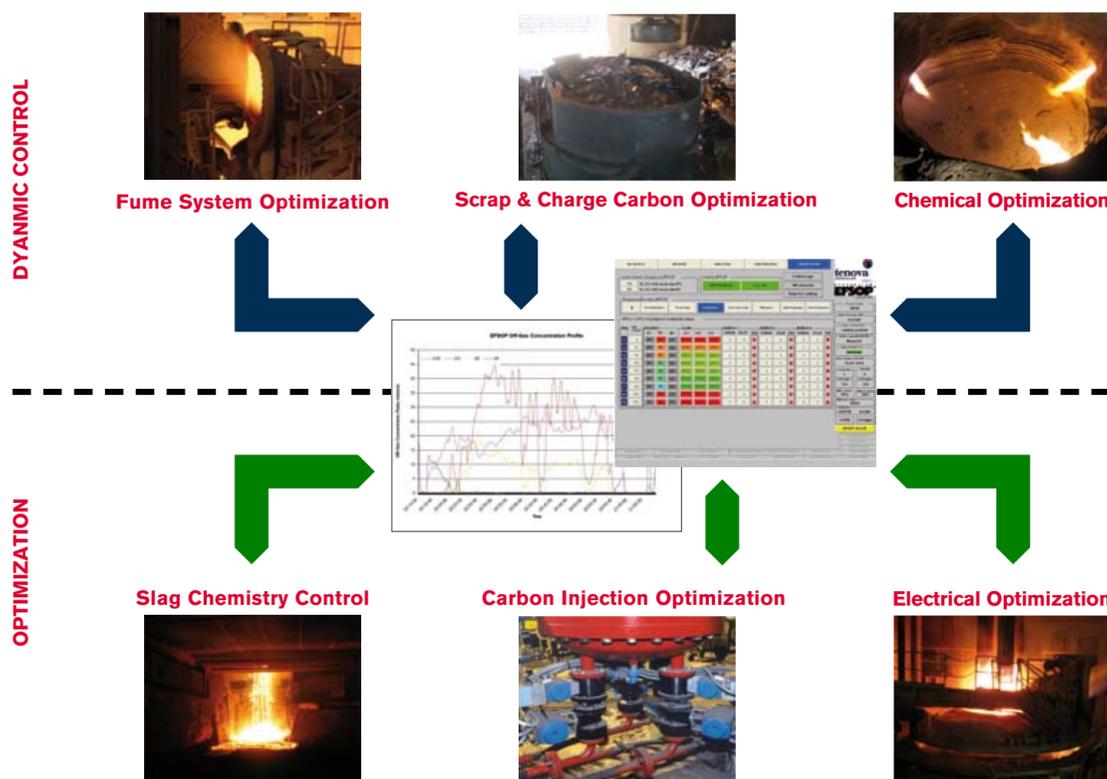
When combined with other process sensors and information EFSOP® technology has proven to be an effective tool for identifying statistically abnormal off-gas composition including water, thereby increasing melt shop safety.

## GOODFELLOW EFSOP® PROBE LOCATION

Developed through an extensive design and continuous improvement process, the patented EFSOP® probe is well suited to survive the harsh EAF environment.



## EFSOP HOLISTIC OPTIMIZATION™ METHODS

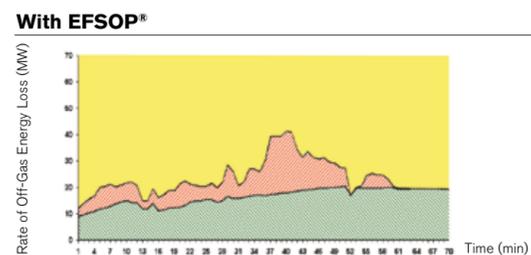
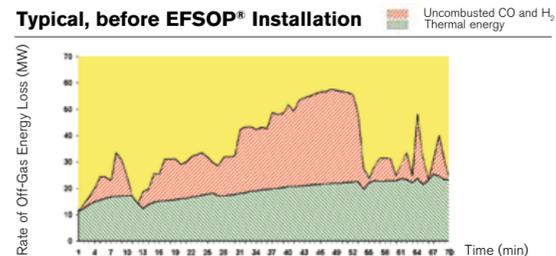


## EFSOP® OPTIMIZATION METHODOLOGY

- Establish EAF standard practice: Tenova engineers use real-time EFSOP® data together with their extensive expertise to develop a comprehensive understanding of the existing process to identify opportunities to improve energy efficiency, reduce costs and increase productivity & yield.
- Establish optimized practice: Tenova engineers use EFSOP® together with "cause & effect" analysis to define, implement & fine tune the optimized practice.
- Implement dynamic closed loop control: savings are locked in with the EFSOP® closed loop control function.
- Verify benefits: electrical & chemical energy improvements, cost savings and productivity & yield benefits are verified with the customer.

## FUME SYSTEM OPTIMIZATION EXAMPLE

Graphs were generated using Tenaris Tamsa, Veracruz chemistry analysis data



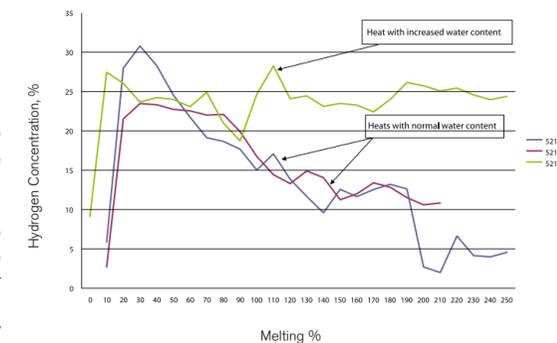
## EFSOP WATER DETECTION TECHNOLOGY™

EFSOP® technology samples and analyzes off-gas chemistry in real-time. When combined with other process sensors and process information has shown to be an effective tool for identifying statistically abnormal off-gas composition including water.

Effective water detection requires knowing both dissociated (H<sub>2</sub>) and undissociated (H<sub>2</sub>O gas) water vapor. When liquid water enters the EAF it immediately forms water vapor (H<sub>2</sub>O gas); a portion of which will dissociate to H<sub>2</sub> gas, leaving the remainder as H<sub>2</sub>O gas.

Unlike laser technology, the EFSOP® system provides accurate and continuous H<sub>2</sub> analysis. And with additional sensors the EFSOP® system is also able to determine the water vapor content in the off-gas. The determination of H<sub>2</sub>O gas in combination with H<sub>2</sub> enables EFSOP® to provide a highly reliable water detection alert that supports operators with a real-time indication when there is a high probability of a water leak.

## Effect of Water Leak on H<sub>2</sub> Concentration



## iSTEEL™ TECHNOLOGY

EFSOP® is the platform used as the basis for the iSTEEL concept: the intelligent application for electric furnaces, oxygen converters and energy recovery.

iSTEEL™ Technology delivers an unparalleled level of value to the customer. It is tailor designed to meet specific customer requirements, providing technical solutions and ongoing customer satisfaction resulting in an improved bottom line in addition to the EFSOP®.

The iSTEEL™ portfolio includes the following solutions:

- iEAF® for EAF dynamic control.
- iBOF® for BOF dynamic control.
- iRecovery® for off-gas energy recovery.

