Nickel Rim South Mine’s Ventilation on Demand System
By Edward McLaren P. Eng
Our Values
We want our employees to be ambassadors for our core Values.

Safety
Our first priority in the workplace is to protect the health and well-being of all our workers. We take a proactive approach to health and safety; our goal is continuous improvement in preventing occupational diseases and injuries.

Entrepreneurialism
Our approach fosters the highest level of professionalism, personal ownership and entrepreneurial spirit in all our employees while never compromising on the safety and well-being of our people. This is important to our success and the superior returns we aim to achieve for all our stakeholders.

Simplicity
We aim to achieve our key deliverables as a path to industry-leading returns, while maintaining a clear focus on excellence, quality, sustainability and continuous improvement in everything we do.

Responsibility
We recognise that our work can have an impact on our society and the environment. We care profoundly about our performance in compliance, environmental protection, human rights and health and safety.

Openness
We value relationships and communication based on integrity, co-operation, transparency and mutual benefit, with our people, our customers, our suppliers, governments and society in general.
General Overview

• Sudbury Integrated Nickel Operations (Sudbury INO) consists of underground mines (Fraser and Nickel Rim South), Strathcona Mill and Sudbury Smelter

• More than 1300 employees

• Nickel-copper mining and processing in the Sudbury area of Northern Ontario, Canada, since 1929

• Nickel and copper are the primary metals; cobalt and precious metals, such as gold, silver, platinum and palladium are also produced
Recent Safety Milestone

• Achieved 5 million hours without a single lost time injury in our integrated business of exploration, mining, milling and smelting activities
2013 Production Rates

• Nickel Rim South Mine
  • 1,322,289 ore tonnes mined

• Fraser Mine
  • 379,720 ore tonnes mined

• Strathcona Mill
  • 2,194,458 ore tonnes milled
  • 26,443 tonnes nickel in concentrate
  • 55,643 tonnes copper in concentrate
  • 607 tonnes cobalt in concentrate

• Sudbury Smelter
  • 75,007 tonnes nickel in matte
  • 20,531 tonnes copper in matte
  • 2,575 tonnes cobalt in matte
Agenda

1. Our History
2. Components of System
3. How the System Functions
4. What it Means to Us
5. Questions
Our History

• **Mid 1980’s -- Omron Timer’s**
  • 1 timer per fan
  • Schedule programmed in the field

• **Early 1990’s – Nano Plc**
  • Similar to Omron in functionality
  • Added benefit of compensating for annual time changes
  • Cheaper in cost

• **Late 1990’s – Twido PLC** by Schneider
  • Capable of controlling multiple devices
  • Remote communication allowing schedule programming from surface
  • Again cheaper in cost

• **Mid 2000’s – Energy One** by Besteck
  • Wonderware based program
  • GUI interface
  • Remote manual control of the equipment
Our History

• 2008 – Nickel Rim South Project
  • Ventilation on Demand System included in the project

• 2009 – VOD Vendor Selected
  • Surface Fans, U/G Regulator & 6 U/G fans automated

• 2010 – Stage 1 & Stage 2
  • Remote control achieved, tracking system integrated

• 2011 – Stage 2 & Stage 3
  • Dynamic flow control proven on level and exhaust fans
  • Ramp break throughs connects mine top to bottom

• 2012 – Stage 2 & Stage 3
  • 1220 Level in dynamic control, AQS in 1480-1535 Ramp

• 2013 – Stage 2 & Stage 3
  • Main vent infrastructure complete, ramp flow control proven out

Stage 1: Remote/Manual Ventilation Control
• Manual control and event scheduling: intelligent HMI for surface/remote control (fans on-off or VFD speed set point, controllable doors, regulators/dampers)

Stage 2: Flow or gas control mode
• Control based on the gas concentration from sensors as well as airflow sensors (PID control loop)

Stage 3: Dynamic VOD
• Flow control via ventilation demand calculation: as a function of personnel location and machinery location & operating status (zone in/out gates coverage to full tracking coverage)
• Optimization control: air flow distribution and surface fans energy
Components of System - Underground Infrastructure

- Shaft Station PLC

Shaft Station PLC’s are located at the main shaft stations on 1280, 1480 & 1660 Levels
Components of System - Underground Infrastructure

- Electrical Substations

Power Control Centres contain controllable fans starter
Automation Control Centre contains the PLC that communicate with these starters
Components of System - Underground Infrastructure

• Air Monitoring Station

The louvers on the regulator are operated using controllable actuators. Air Monitoring Station contains the PLC that communicate with these actuators. Sensor Information is feed to the Air Monitoring Station via 4-20mA signals.
Components of System - Underground Infrastructure

- **Air Quality Station (AQS)**
  Provides CO sensor, flow sensor and temperature sensor information only

- **Air Flow Station (AFS)**
  Provides flow sensor and temperature sensor information only

Not part of the original vision
the AQS and AFS were added to the infrastructure once it was recognized we required sensor information from the ramp areas
Sensor information passed to Automation Control Centre via Ethernet

Similar in appearance,
no gas sensor on mounting board
Components of System - Underground Infrastructure

• Tracking System

Network of Wi-Fi Zone zones track Air Demand Indicators, and VOIP phones based on intensity of signal
Components of System - Communication Infrastructure
How the System Functions – Rockwell HMI

Rockwell HMI – the base for all site automation

Four of the Rockwell Systems together control the mine ventilation
How the System Functions – VOD HMI

VOD HMI – Summary Screen

Colours are used to allow quick system status determination

Green is good
The darker the green the higher the level of control

Yellow indicate control type problems

Red indicates field problems

This screen is always open in the back ground
How the System Functions – VOD HMI

VOD – Surface Fans: Intake & Exhaust

Intake and Exhaust Fans can be set at a given speed (manual) or a given flow control.

Exhaust fan can also be set to dynamic control.

In Dynamic Control Exhaust Fan speed adjusts to maintain regulators at 80% open or less.
How the System Functions – VOD HMI

Auxiliary fans controls are accessed through their respective level plan

Fan icons are located on the heading that they ventilate, not where installed

Side bar indicates status
Green is on, Black is off

Sub Bar provides mode and fill colour indicates status

Fan Modes
Man – Manual On / Off
VOD – Dynamic Control
Rem – Remote AB Control
Loc – Control in field

Green is good
Yellow or Red, the fan is not controllable
How the System Functions – VOD HMI

VOD-HMI Regulator Face Plate – accessed off Summary or Level Screen

Left Clicking the SP: box brings up the Input Dialog box allowing Set point to be changed.

Desired flow in cms through regulator, % open if mode is Manual.

Regulator Modes
- Manual – Louvers opened to % open SP
- Flow – Louvers controlled to maintain cms SP
- VOD – Louvers controlled meet level demand

SP = Set Point
How the System Functions – VOD HMI

**Level Response**
- No Activity 8 cms
- 1 Worker 10 cms
- 2 Workers & 1 Utility vehicle 10 cms
  » Diesel Demand 6.8 cms
- Level Flow rises to satisfy demand
- 1 Stope Fan operating nothing on the level 23.6 cms (min)

**Stope Access Response**
- Stope Access fan will start within 10 seconds of worker or equipment being 10m inside the access
- Worker is responsible to ensure fan is working
- 15 minutes after the last worker or vehicle leaves the area the fan stops
What is an Event?

It is a set of command instructions to controllable equipment.

This can include delay timing, mode, and set point such as speed or % open or on or off or cms flow.

Only one set of instructions per piece of equipment is allowed per event.
How the System Functions – VOD HMI

VOD-HMI Scheduling Screen – Schedules

<table>
<thead>
<tr>
<th>Scheduling Report</th>
<th>Schedule</th>
</tr>
</thead>
<tbody>
<tr>
<td>User defined events</td>
<td>Name</td>
</tr>
<tr>
<td>Manage Events</td>
<td>Exhaust Fan Ramp Down</td>
</tr>
<tr>
<td>Add event to schedule</td>
<td>2 - Intake Fans Into Row Co.</td>
</tr>
<tr>
<td>Edit scheduled event configuration</td>
<td>Regulator Open 100%</td>
</tr>
<tr>
<td>Edit scheduled event timing</td>
<td>1 - Exhaust and Intake Fans</td>
</tr>
<tr>
<td>Delete event from schedule</td>
<td>2 - Intake Fans Into Row Co.</td>
</tr>
<tr>
<td>Start event from schedule</td>
<td>SA Aux. Fan Start-up excl...</td>
</tr>
<tr>
<td>Start an event</td>
<td>3 - Normal regulator position</td>
</tr>
<tr>
<td>Scheduling Log</td>
<td>4 - Flow control regulators</td>
</tr>
<tr>
<td>Fan ctrl. system events</td>
<td>Pre-Operational services au...</td>
</tr>
<tr>
<td>Pre-blast shutdown</td>
<td>Operational service fans sta...</td>
</tr>
<tr>
<td></td>
<td>Op. service fans dynamic c...</td>
</tr>
<tr>
<td></td>
<td>SA Fans dynamic control</td>
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<td></td>
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</tr>
<tr>
<td></td>
<td>SA Fans dynamic control</td>
</tr>
</tbody>
</table>

Scheduling Log reports the success of each events that has been run

What is a Schedule?

It is a command to run an event at a given time. Schedules are discrete, subsequent schedules are not prevented from changing equipment instructions from previously run events

13 daily reoccurring User Defined events for each day shift
How the System Functions – Upset Conditions

Rockwell HMI & VOD HMI Responses

- **Lost Communication** *(nothing is changed, control removed)*

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<tr>
<th>Equipment</th>
<th>Rockwell HMI</th>
<th>Control to VOD HMI</th>
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</thead>
<tbody>
<tr>
<td>Surface Fans</td>
<td>Mode switches to remote</td>
<td>Control Removed</td>
</tr>
<tr>
<td>Regulators</td>
<td>Mode switches to remote</td>
<td>Control Removed</td>
</tr>
<tr>
<td>Auxiliary Fans</td>
<td>Mode switches to remote</td>
<td>Control Removed</td>
</tr>
</tbody>
</table>

- **Restoration of Power**

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<tr>
<th>Equipment</th>
<th>Rockwell HMI</th>
<th>Control to VOD HMI</th>
<th>VOD in Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surface Fans</td>
<td>Mode switches to remote</td>
<td>Need to re-set</td>
<td>Intake fan – resume</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Exhaust fan - manual</td>
</tr>
<tr>
<td>Regulators</td>
<td>Mode switches to remote</td>
<td>Need to re-set</td>
<td>Manual</td>
</tr>
<tr>
<td>Auxiliary Fans</td>
<td>Mode switches to remote</td>
<td>Need to re-set</td>
<td>Manual</td>
</tr>
<tr>
<td></td>
<td>Mode returns to that just</td>
<td>Control resumes</td>
<td>Manual</td>
</tr>
<tr>
<td></td>
<td>prior to interruption</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
# How the System Functions – VOD HMI

## VOD-HMI Scheduling Screen – In the Hands of Operations

<table>
<thead>
<tr>
<th>Action</th>
<th>Operations Centre Supervisor</th>
<th>Development Supervisor</th>
<th>Production Supervisor</th>
<th>Beat Electrician</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stop/Start U/G Fans</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Take Fan out of Dynamic Control</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Adjust Exhaust Fan RPM</td>
<td>✓</td>
<td></td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Start an Event</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Postpone Event</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adjust Regulators</td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
</tr>
</tbody>
</table>
How the System Functions – VOD HMI

VOD-HMI Scheduling Screen – Ramp Control

• Regulators were quite capable of realizing demanded flow of 25 cms readily
• Maintaining Ramp flows was more of a challenge than anticipated
• Tried a number of complicated approaches to try to achieve ramp flow
• Found simple approach most reliable
  » Regulator that has greatest influence on a given ramp is used to control ramp flows
  » Some regulators do influence more than one ramp which can result in over ventilating a given ramp
  » Control logic for this method is simple and effective
What it Means to Us

• Continue with expansion of VOD infrastructure
What it Means to Us

- Information in the hands of operations
- Ability to monitor and stop / start fans remotely
- Ability to monitor and react to upset conditions
- Ability to optimize production blast gas clearing
- Ability to reduce ventilation flow where not required
What it Means to Us

• Ventilation Where It Is Needed
  » Tailored to weekly schedule
  » Flushing inactive headings
  » Optimized flows

• Reduced Environmental Impact
  » Electricity
  » Natural Gas
  » Surface Noise