2nd International Mine Rescue Conference

November 2005

Ian Houlison- Phoenix First Response
- presently at mine fire in Colorado
Patti Meyer- Weatherford International

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USA

- Early 21st Century- first successful utilization of GAG (Jet engine) system in US:
- Collaborative effort of
  - Consol Energy- Major Coal Producer
  - Queensland Mines Rescue Service
  - Micon- US Polyurethane Specialist
  - MSHA- Dept. of Labor, Mine Safety & Health Admin.
  - NIOSH- National Institute of Occupational Safety & Health
  - UMW- United Mine Workers Union representing workers

Set the stage for the multi-disciplined approach to response systems

GAG- 234 million cubic meters over 21 days

N2- 36.27 million cubic meters over 60 days to maintain oxygen depleted zone

Revealed the need for Single Contact Point
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Mission Statement

Provide timely and rapid intervention to thermal events that impact the United States mining industry

Goal

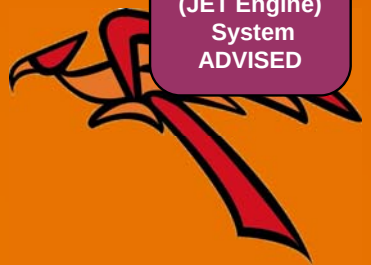
To supply a single contact point for response to mines in need of assistance 24 hours per day, 7 days a week

How does this work?

- The initial telephone contact to Phoenix puts all partnering agencies to alert phase.
- Phoenix meets with mine management and MSHA as to the problem and advises most appropriate level of response after peer group committee gives its endorsement and risk mitigation principles have been completed

THERMAL EVENT IN AN UNDERGROUND COAL MINE

- NOTIFICATION to MSHA
- TELEPHONE call to PHOENIX FIRST RESPONSE
- NOTIFICATION to STATE INSPECTORS
- Mobile Poly Urethane Team {PUR} (MICON) ADVISED
- PEER Group assembled for deliberation on the issues (PHOENIX First Response)
- GAG (JET Engine) System ADVISED
- Diaphragm Nitrogen Plants (Weatherford) ADVISED
- Liquid Nitrogen Plants (Halliburton) ADVISED
- Nitrogen filled Foam Companies ADVISED
- Underground Stoppings and Seals (MICON) ADVISED
- Mutual Assistance Groups (Neighboring Mines) ADVISED
- Down Hole Camera (Weatherford) ADVISED



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Thermal Events USA- 2003+

- Seven- last one ongoing
- All utilizing some or all of the following:
- Portal sealing, Membrane Nitrogen, Liquid Nitrogen, GAG System, Nitrogen Foam
- Two using GAG system
- Six using Membrane Technology

GAG 3A System

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The GAG 3A System

- Has been used successfully in:
  - Poland,
  - South Africa,
  - Australia and
  - The United States

The GAG 3A System

- Uses a jet engine and afterburner to create Stoiometric Combustion (Absolute Combustion)
- The system produces:
  - High levels of carbon dioxide
  - Low levels of oxygen
  - Large amounts of steam reducing latent heat

The GAG 3A System

Input to Engine	Output to Mine
21% Oxygen	2% Oxygen
78% Nitrogen	73% Nitrogen
0.03% Carbon Dioxide	25% Carbon Dioxide
	464 Gallons of Water (Vapor form)

RESOURCES

- GAG System
  - 2 Jet engines
  - Control gates
  - Water controls
  - Containerized control systems

Advantages of the GAG 3A System

- Rapid deployment for large amount of inert product
- Creates an oxygen deficient atmosphere (2% or less) in a relatively short time
- Easily obtainable operational requirements
- Greatly reduces re-entry time to stabilize environment
- Mine Resumes production in considerably less time than conventional methods

The GAG 3A System

- May be installed at a pre-fabricated docking facility at deep mines.
- PHOENIX First Response researches, designs and builds docking facilities around the US.

GAG 3A System Operations

- Team Size
  - 6 members on each team
  - 3 teams per day
- Shift Time
  - 8 Hour Maximum for long duration response (in excess of 80 hours)
- Weather
  - Risk assessment recommended

Nitrogen Membrane Technology

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Resources

- NPU’s (Nitrogen Production Units) generate Nitrogen on-site from compressed air

Resources

- Portable
- Stackable Units, Truck Mounted, Skid Mounted, Containerized
- Purities from 92% to 99% Nitrogen with Oxygen Balance
- Dewpoints to -90 F

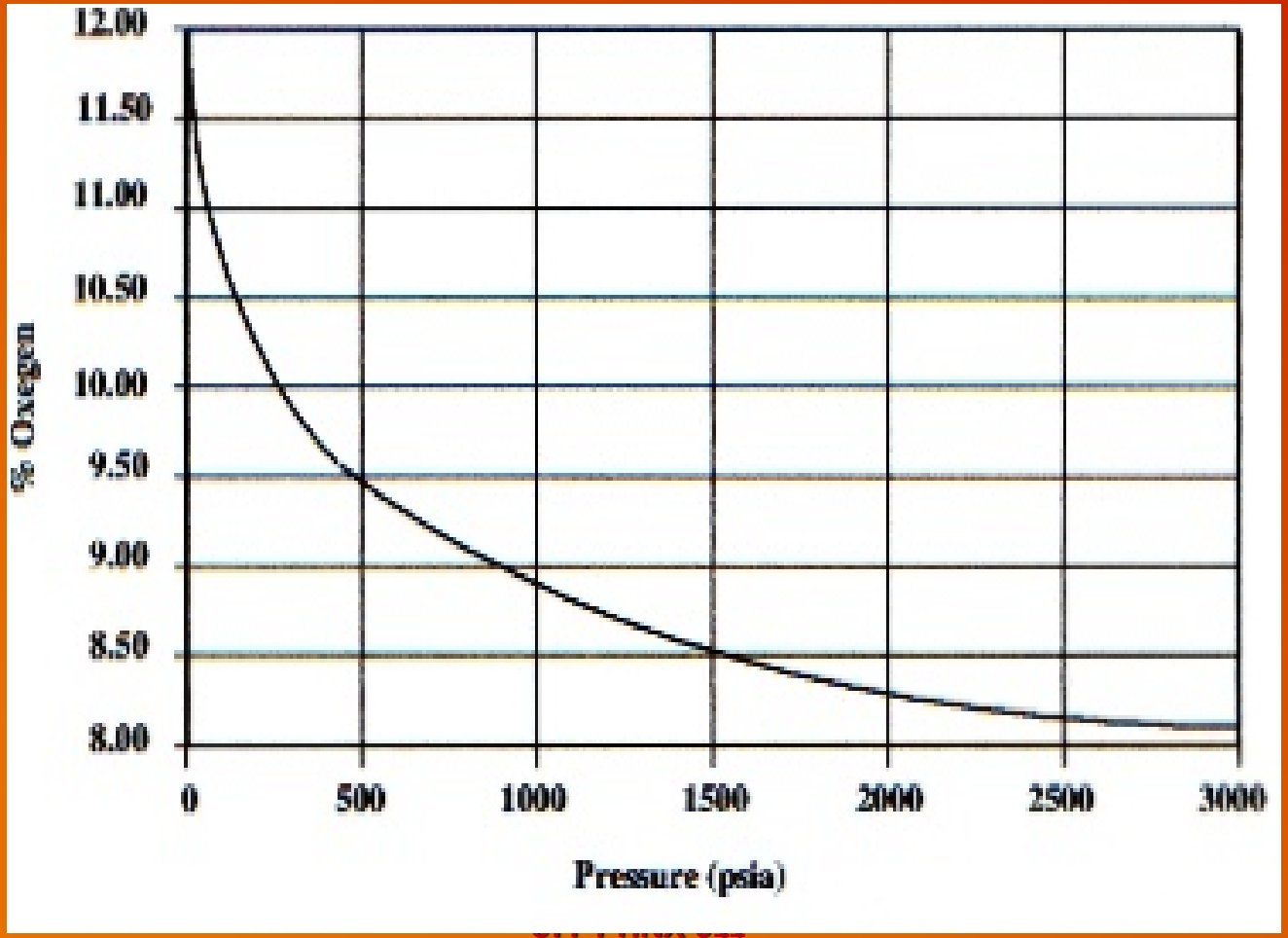
Nitrogen Conversion

	Weight		Gas		Liquid	
	pounds (lb)	kilograms (kg)	cubic feet (scf)	cu meters (Nm^3)	gallons (gal)	liters (l)
1 pound	1	0.4536	13.803	0.3627	0.1481	0.5606
1 kilogram	2.205	1	30.42	0.7996	0.3262	1.2349
1 scf gas	0.07245	0.03286	1	0.02628	0.01074	0.04065
1 Nm^3 gas	2.757	1.2506	38.04	1	0.408	1.5443
1 gallon liquid	6.745	3.06	93.11	2.447	1	3.785
1 liter liquid	1.782	0.8083	24.6	0.6464	0.2642	1
1 short ton	2000	907.2	27605	725.4	296.2	1121

Weatherford NPU Unit Specifications

Weatherford Units (95% Purity)	Pounds (lb) - Per Hour	Kilograms (kg) - Per Hour	Cubic Feet (scf) - Per Hour	Meters (Nm3) - Per hour	Gallons (gal) - Per Hour	Liters (l) - Per Hour
550 SCFM			33,000	867.5	354	
750 SCFM			45,000	1,183	483	
950 SCFM			57,000	1,498	612	
1500 SCFM			90,000	2,366	966	
2000 SCFM			120,000	3,155	1,289	
2250 SCFM			135,000	3,549	1,450	
3000 SCFM			180,000	4,732	1,933	

Minimum Oxygen Required for Combustion of an Oxygen-Methane-Nitrogen Mixture (Allan, 1994)



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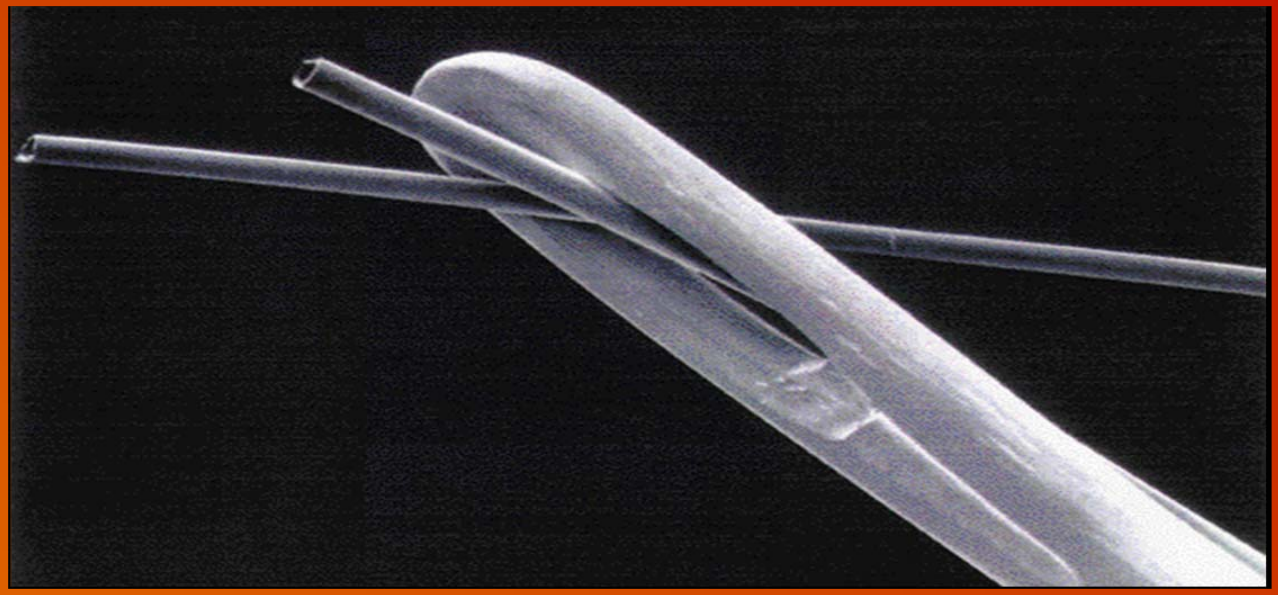

Each individual membrane is perfectly hollow, about the size of a human hair.

The polymeric fibers are based on decades of membrane separation technology and polymer science.

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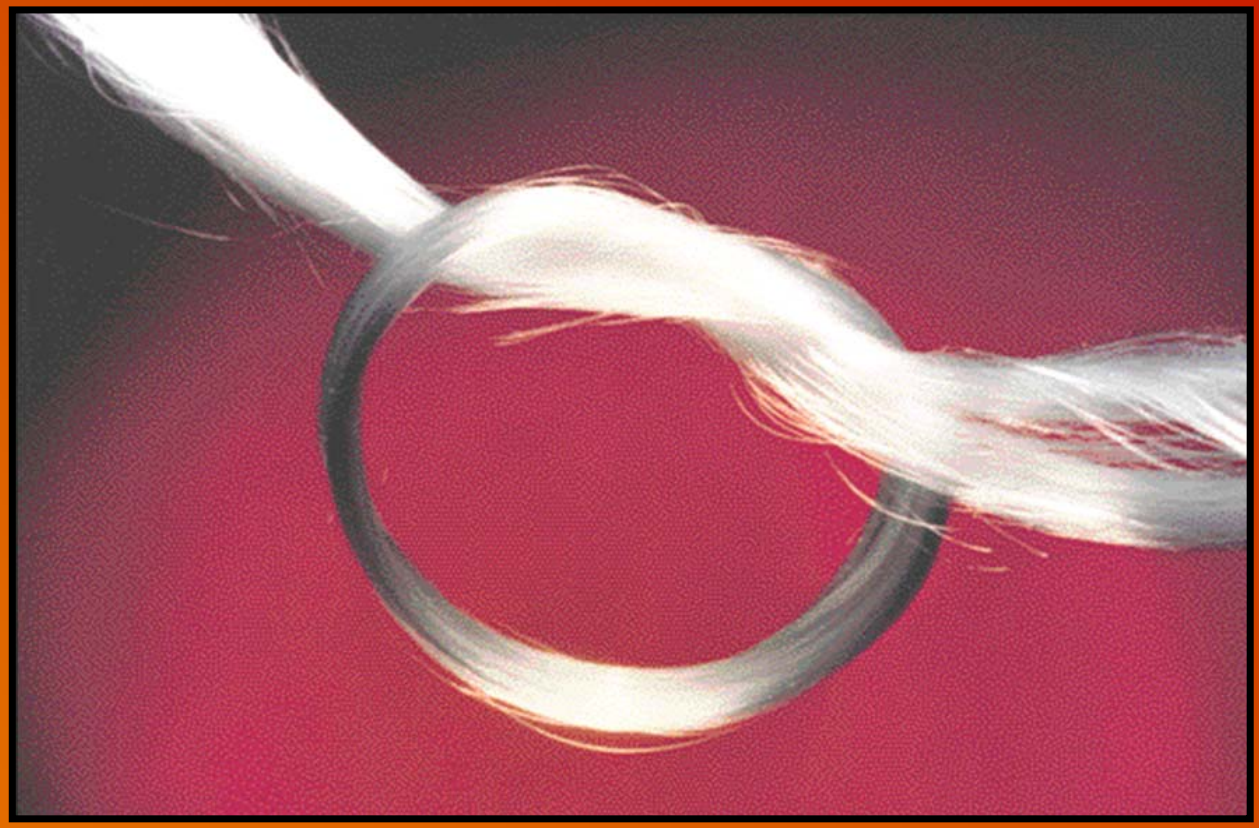
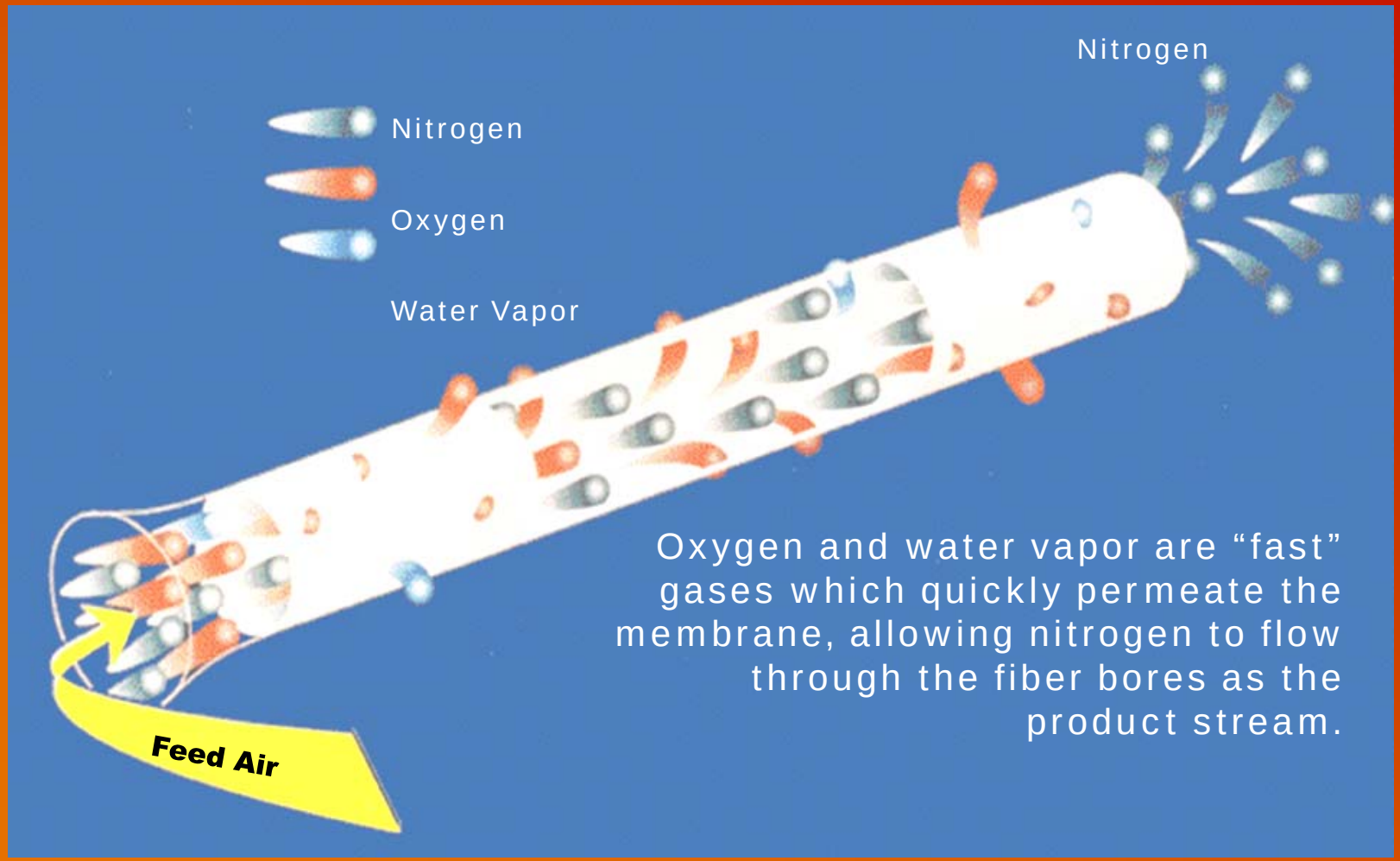
Nitrogen Membrane Technology

- Thousands of miles of hollow fiber membranes make up each membrane module





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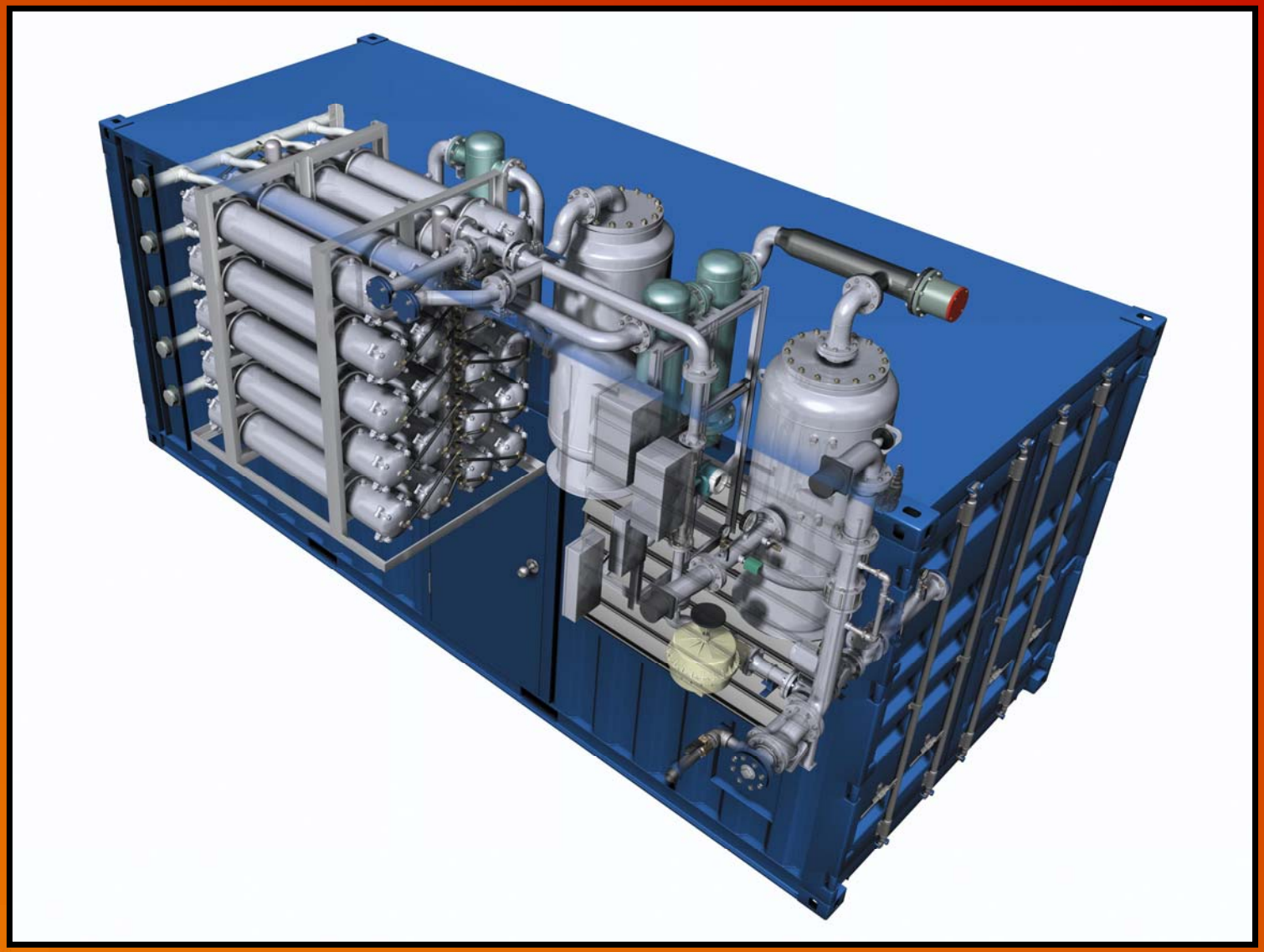

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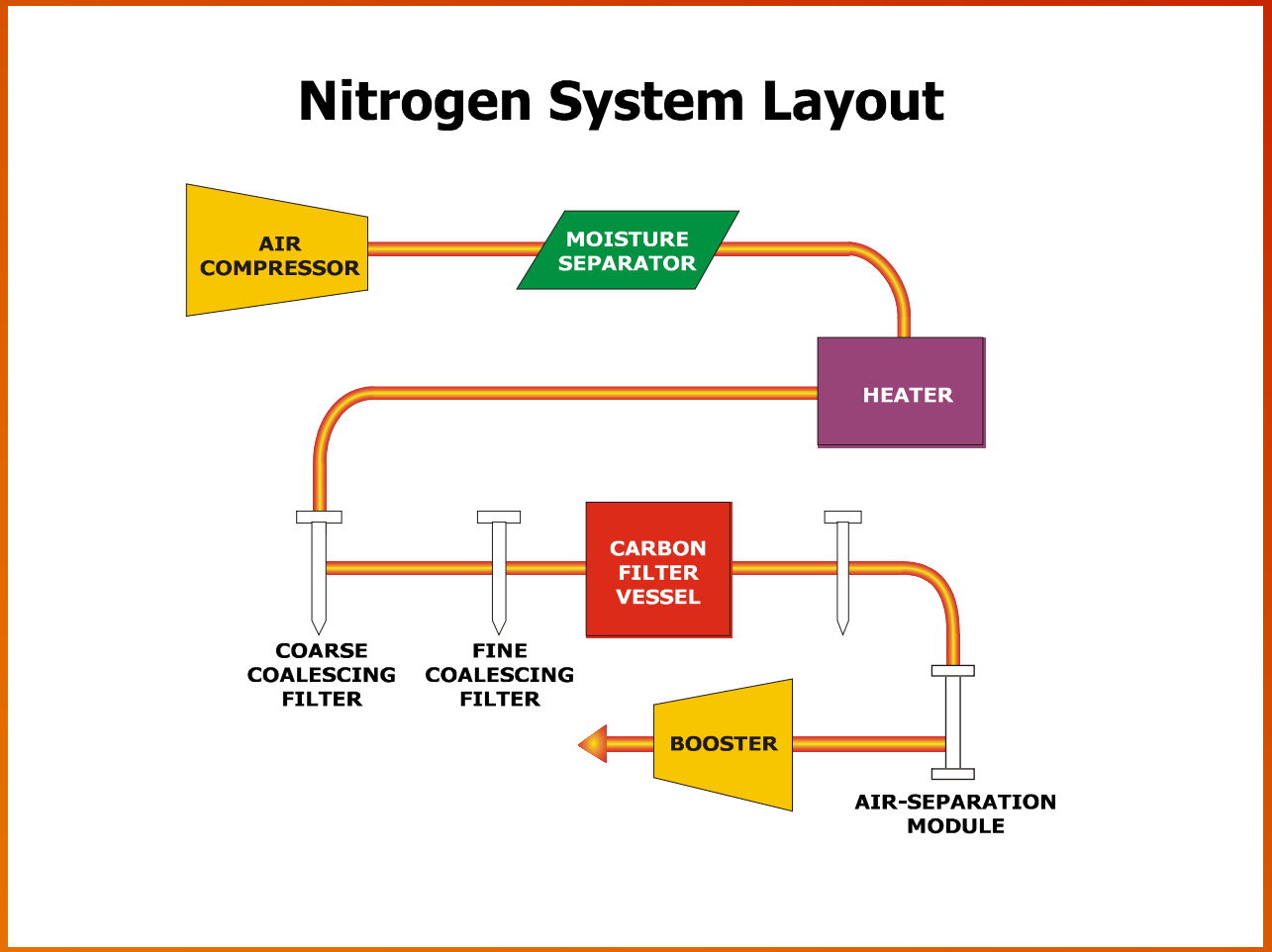
Nitrogen System Layout



Purity and Flow Control System

- The PLC control panel regulates product purity and flow by monitoring and compensating for changes in ambient feed air temperature, humidity, and elevation pressure. Because of the nature of membranes these must be managed for consistent purity control.

NPU 1500

- Specifications
  - Footprint: 8’x8’x10’
  - Flow: 1,500 scfm

West Virginia

- Total volume pumped
  3,355,546^{3m}
- Spread one- 56 days @22.65^{3}m/min
- Spread two- 87 days @ 14.16^{3}m/min

West Virginia

60 days
Total volume
Pumped= 3,369,705 ^{3}m

Virginia

Spread one- 42.47^{3}m/min
Spread two- 15.57^{3}m/min

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Nitrogen Pumps

- **Up to 16,667 SCF/Min Capability**
- **186,000 SCF N2 Storage (2000 Gals)**
- **Standard 10,000 psi WP**
  - **Packages for up to 15K**

Nitrogen Transports

- **800,000 SCF N2 Storage (8600 Gals)**
- **Full support for all pumping needs**

Advantages of Membrane Nitrogen

Non-cryogenic/ SAFER

Small Footprint

Easily Transportable

Diesel or Electric Driven

Cost effective vs. liquid cryogenic Nitrogen

Case Study

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Case Study-Virginia 2005 USA

- **Possible frictional ignition occurred with an associated roof fall that caused elevated levels of methane to be present in the longwall face area. Initial section evacuation.**
- **Next event was total mine evacuation due to elevated levels of carbon monoxide.**
- **Call to Phoenix who mobilized to headquarters and put all partnering agencies on alert.**

Case Study

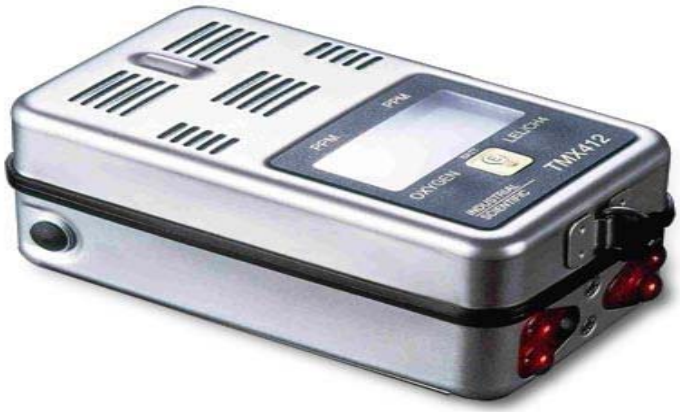
- **Decision to seal the mine was given approx. 26 hours into the event as a controllable condition was unlikely.**
- **Mine management team reacted quickly to prepare to seal the mine and all plant, equipment, and supplies were positioned in place at all nine portals.**

Planning Phase

- Tasks being allocated included:
- Hazard Management plan was set up with training certification being established
- Underground mine condition monitoring was established
- More secure seal of mine (air tight seal)
- Nitrogen Units and Nitrogen Foam called out
- Contact to Australia and Poland to assist with the GAG system
- Management structure for the event was established

Monitoring

- Three systems utilized:
- Hand held instruments assigned to mines rescue team members to ensure safe atmospheric zone around the portals
- Samples conveyed to a gas chromatograph
- Fixed systems catalogued every half hour, then hourly on all sites



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Portal Sealing

- Needed more substantial seals:
- Initial sealing was a Micon product 550-10 of weighted polyurethane.
- Later upgraded to denser RokLoc 70
- Also, a relief valve was fabricated utilizing plastic conduit pipe with pre-weighted ball valve arrangement

Portal Sealing

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Nitrogen & Nitrogen Filled Foam

- Membrane Nitrogen was staged at most portals with technicians assigned to each site affording a 24 hour per day operational status.
- Nitrogen foam has been tested in the US and was found effective. Currently undergoing upgrades to add additional controls. Utilized extensively at this event.

International Response

- Two GAG engines were prepared for application at two portal locations.
- Additional manning requirements led to the Polish Central Mines Rescue Station and Queensland Mines Rescue Service being contacted.
- Due to improved underground conditions, the GAG was not utilized on this event.

Management Structure

- Setting up a line management structure was intrinsic to its success.
- Forward command posts were set up for the major responding agencies.

Response Phase

- MSHA Notification
- State Government Notification
- Emergency Sealing
- Final Sealing and Maintenance

Sealing

- Emergency Seals fabricated with timber, brattice cloth and commercially available light foam packs with underlying steel bracing.
- Found need for more durable seals and Micon installed poly urethane seals at varying strengths.

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Re-entry Phase

- Dry ice applied through a cutting tip under pressure was found to be a safe and expeditious method to remove the seals.
- Risk mitigation process was applied

Control Measures

- Fall arrest devices for all personnel within 30 foot radius of openings
- Constant atmospheric monitoring
- Limited number of people in area
- Communication bases
- Back-up resources

Proceeding Underground

- Pre-planned documented sequential arrangement which involved 1,000 foot excursion into oxygen reduced atmosphere.
- Re-established ventilation underground 1,000 feet at a time permitting fresh air base to always be close at hand.

Conclusion

- Phoenix philosophy bringing all parties together has proven record.
- Mines rescue involvement intrinsic to timely success to an event in the coal industry.

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THANK YOU