





Risk Assessment & Loss Prevention Of Hazards Associated With The Carriage Of Coal

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Background



- Coal Included In IMO Publication
“Code Of Safe Practice For Solid Bulk Cargoes”
- Code States That Coal May :
 - Spontaneously Heat
 - Create Flammable Atmospheres
 - Corrode Metal Structures
 - Liquefy
 - Generate Asphyxiation Hazards



Background



- Early Classification Of Coal In BC Code :

Observations

For transport purposes coal may be placed in one of four categories:

CATEGORY A Coal cargoes of a type that can be identified as having a history of shipment under similar circumstances without problems arising from methane emission or spontaneous heating.

CATEGORY B Coal that has shown itself liable, or may be liable, to emit methane in quantities sufficient to create a hazard.

CATEGORY C Coal that has shown itself liable, or may be liable, to spontaneous heating.

CATEGORY D Coal that has shown itself liable, or may be liable, to emit methane in quantities sufficient to create a hazard and be subject to spontaneous heating.

Many Shippers Declared Coals
As Category "A" Despite
Previous Incidents Of Methane
Explosion Or Heating

The Code Contained No Detailed
Methods Of Test For Methane Or
Temperature Measurement Of
The Coal Cargoes



Background



- In 1990 MTD Instructed By International Group Of P&I Clubs & Salvage Association
- Form Part Of Coal Sub-Committee Relating To Revision Of IMO BC Code
- Work Included Investigation Into:
 - Measurement Of Carbon Monoxide In Holds
 - Measurement Of Oxygen In Holds



Spontaneous Heating



- Immediately A Coal Is Mined Subject To:
 - A Chemical Process Whereby Oxygen Reacts With Coal
 - A Physical Process Whereby Coal Tends To Disintegrate Into Smaller Pieces
 - Second Process Increased By Handling & Weathering
 - As A Result Of Second Process More surfaces Of Coal Are Exposed to React With Oxygen



Spontaneous Heating



- Oxidation Of Coal In A Stockpile (Or Hold) Generates Heat
- A Mass Of Coal (In A Stockpile Or Hold) Is A POOR Conductor Of Heat
- Rate Of Temperature Rise In Stockpiles (Or Holds):
 - Ambient To 80°C = Slow Rise*
 - At 100°C = Temperature Remains Constant Until All Moisture In Coal Is Evaporated Off*
 - Above 100°C = Rapid Rise To Ignition Temperature Of Coal (400°C Depending On Type Of Coal)*



Spontaneous Heating



- Quality Parameters That Can Be Affected By Poor Storage (& Carriage) Practices
 - Loss In Calorific Value (CV)
 - Loss In Coking Properties In Coking Coals
- Good Stockpiling (& Carriage) Practices Have Been Shown To Preserve These Quality Parameters



Spontaneous Heating Coal Stockpiles



- Oxygen Is Essential For Oxidation Process
- Loose Piling Of Stockpile





Spontaneous Heating Coal Stockpiles



- Loose Piling Of Stockpile

Wind Effects Create Air (Oxygen) Flow Into Pile

Chimney Effect Whereby Gases & Hot Air Rise To
Top Of Pile & Fresh Air (Oxygen) Drawn Into
Bottom



Spontaneous Heating Coal Stockpiles



Heating Cycle Becomes Established Leading To....



The Wrong Way To
Measure Temperature





Spontaneous Heating Coal Stockpiles



Compact Piling Of Stockpile

Whale Back Shape

Minimise Air Flows/Penetration



“Result Of An Extremely Expensive Exercise”



Spontaneous Heating

Case Study : US Gulf Ports Coal Exports



- Case Involves Shipments Of High Grade Coking & Steam Coals
- Previously Shipped By Rail To East Coast Ports For Export (Journey Few Days)
- Congestion At East Coast Ports Meant Coal Shipped By Barge To Gulf Coast Ports For Export (Journey Few Weeks)



Spontaneous Heating

Case Study : US Gulf Ports Coal Exports



- Problem :
 - Coal Loaded Into Barges In Conical Piles
 - Warm Mississippi Air Drawn Into Bottom Of Piles Creating A Natural Chimney Heating Effect





Spontaneous Heating

Case Study : US Gulf Ports Coal Exports



- Solution :
Trim The Barges Level To Minimise Air Ingress, Heating & Chimney Effect





Spontaneous Heating

Case Study : Columbian Coal Exports



- Ship Loading
- Equipment Available To “Load” Coal Into Corners Of The Holds





Spontaneous Heating

Case Study : Columbian Coal Exports



- Ship Trimming
- Level Trim Achieved In Holds





Flammable Atmospheres



- Methane Major Constituent Of Gases Produced By The Decay Of Organic Matter
- Methane Contents Of Coal
 - Anthracite 23m³/t
 - Bituminous Coal 0.03m³/t
- IMO BC Code Recognizes Hazard & Recommends :
 - Hold Atmosphere Testing
 - Cargo Compartment Ventilation



Flammable Atmospheres

Case Study : Coal From Nova Scotia



- Number Of Incidents Of Explosions On Ships Carrying Coals From Nova Scotia
- Explosions Resulted In :
 - Damage to Ships
 - Personal Injuries
 - Loss Of Life



Flammable Atmospheres

Case Study : Coal From Nova Scotia



- Master Given Following Information :

“...Coal was likely to be freshly mined at the time of loading & was liable to emit greater quantities of methane at the time of loading & during the early part of the voyage than other coals loaded for carriage by sea...”
- Precautions Listed Included :
 - Continuous Surface Ventilation Of Cargo
 - Reinforce Ventilation By Opening The Cargo Hatches When Possible
 - Prevent Source Of Ignition
 - Electrical Equipment To Be Isolated
 - No Smoking

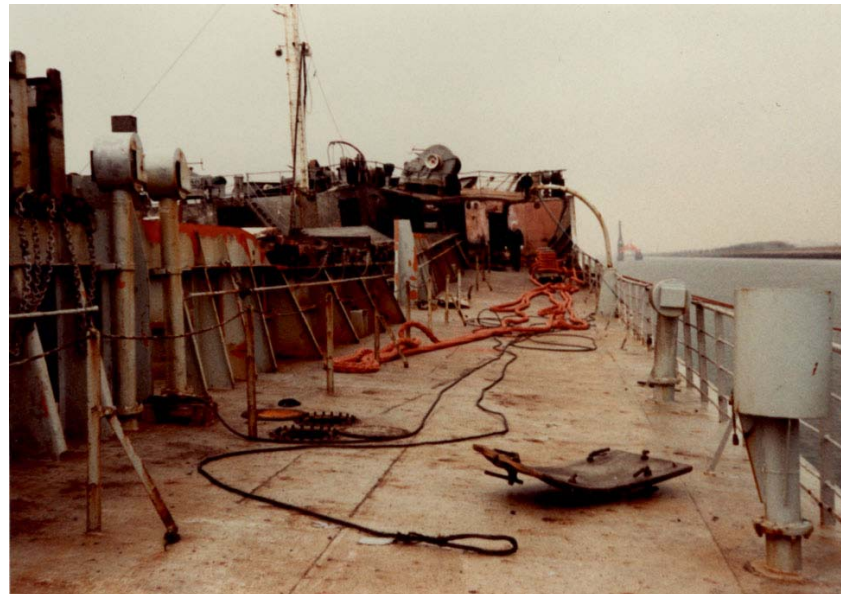


Flammable Atmospheres

Case Study : Coal From Nova Scotia



- During Voyage A Series Of Explosions Occurred :





Flammable Atmospheres

Case Study : Coal From Nova Scotia



- Following A Detailed Study Of Incident Including A Review Of The Nova Scotia Mining Activities, The Following Was Concluded :
 - The Coal Shipped Was Only A Moderately “Gassy” Coal Compared With Anthracite Coals ($9\text{m}^3/\text{t}$)
 - The Ventilation Structure Of The Carrying Vessel Was Not Suitable To Carry A Coal Cargo Which Would Emit Flammable Gases



Corrosion



- Sulphur Present In Many Coals
- Reaction Of Sulphur With Moisture Leads To The Formation Of :
 - Sulphurous & Sulphuric Acid
- Acids Produced Will Attack Steel Surfaces Including Shell Plating & Framing



Corrosion



- Rate Of Reaction Of Sulphur & Moisture Increased By Temperature
- Any Spontaneous Heating Of Coal Will Increase Rate Of Acid Production
- Acid Production Can Even Occur In Stockpiles





Liquefaction & Stability



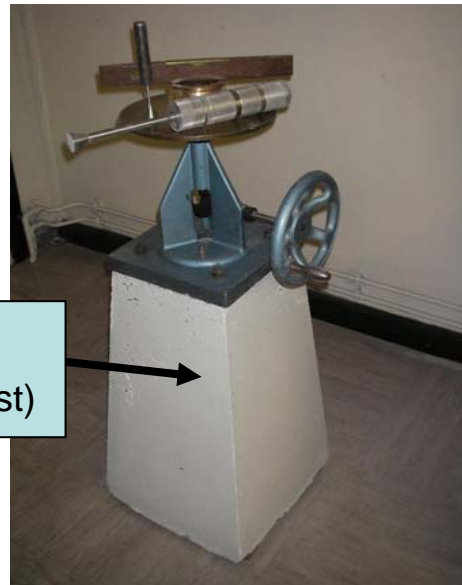
- Coal Often Shipped In Finely Divided Form
- At High Moisture Content Coal Mass Will Behave As A Slurry
- “Sliding” Movement Of Stow Can Lead To Listing Of Carrying Vessel & Potential For Capsize
- Test Coal To Ascertain Flow Moisture Point (FMP) & Transportable Moisture Limit (TML)
- $TML = 90\% \text{ FMP}$



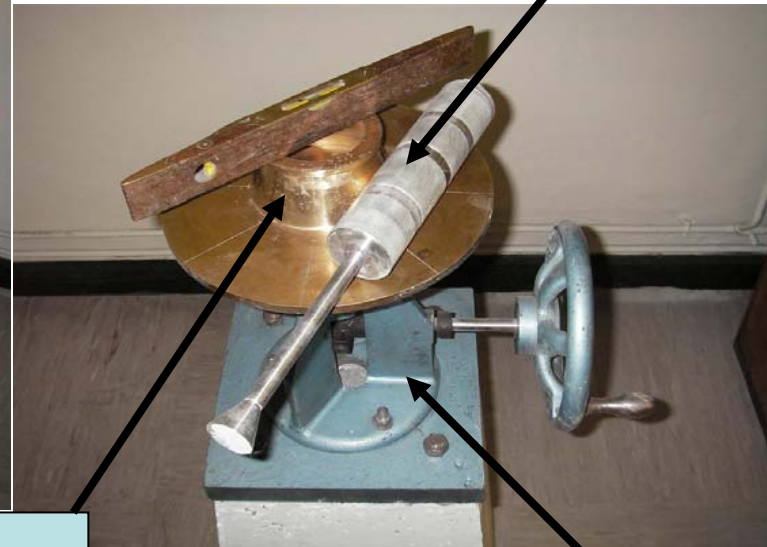
Liquefaction & Stability



Flow Table Test To Measure FMP



Plinth
(Stability For Test)



Brass Mould
(To Form Up Test "Pudding")

Spring Loaded Tamper
(To Get Accurate Tamping For Expected Height Of Cargo)

Flow Table
(With Rotating Cam To Simulate Ship Motion)



Liquefaction & Stability



- Examples Of Stockpiles In Excess of TML



- Such Wet Cargoes Should Be Rejected For Shipment



Asphyxiation Hazards



- When Coal Oxidises Reduces Oxygen Content In A Hold

Oxygen Level (%)	20.8%	16.0%	14.0%	10.0%	6.0%
Effect	Normal Atmosphere	Breathing & Pulse Rate Increases	Judgement Is Effected	Movement Is Restricted	Breathing Stops



Asphyxiation Hazards



- Oxidation Also Produces Carbon Monoxide
- This Is Highly Toxic & Exposure To Concentrations Of 0.4% For Less Than An Hour Can Be Fatal
- Presence Of Carbon Monoxide Nor Deficiency Of Oxygen Can Be Detected By Odour Or Colour
- Adequate Testing By Competent Persons Using Calibrated Test Instruments Is Essential Prior To Entry Into Cargo Spaces And Adjoining Spaces



Regulation



The IMO BC Code Now Requires :

- Spontaneous Heating
- Flammable Atmospheres
- Corrosion
- Liquefaction
- Asphyxiation Hazard
- Level Trimming Of Cargo
- Good Hold Sealing (Including Use Of Tape)
- Monitoring Of Hold Atmosphere
- Monitoring Of Hold Atmosphere
- Cargo Compartment Ventilation During 1st Day
- pH Monitoring Of Bilge Samples
- Regular Pumping Of Bilges
- Application Of TML Testing BEFORE Shipment
- Hold Atmosphere Testing Before Entry Into Hold
- Need For Responsible Person In Constant Attendance



Conclusions



- This All Works
- With The Result That :

“...When MTD are now requested for advice on the carriage of Coal by an Underwriter or a P&I Club Member, we are now able to state that there should be no problems if the coal is carried strictly in accordance with the current recommendations of the I.M.O. BC Code ...”