MINING TEST METHODS

Large-scale Tests

Simulated Mine Stope

The practice of treating mining timber with fire retardant chemicals has been commonly used underground in the mining industry in South Africa for many years.

FIRELAB performs a set of comparative large-scale fire propagation evaluations in its **Simulated Mine Stope** facility. The results obtained during an evaluation on timber treated with fire retardants are compared to that of an evaluation on untreated timber.

However, no fire retardant treatment system is effective without the use of an auditable **Quality Assurance Program** (**QAP**), verified by annual and quarterly testing. If a **QAP** is not followed it cannot be guaranteed that the same standard of the timber used during this evaluation is delivered to the mines on a continual basis.

Timber mine supports would include the following:

- Mine support packs of all configurations
- Elongates (timber props and combinations thereof)
- Hydraulic jacks.

Timber Mine Supports (Large-scale Burn test)

The simulated mine stope test facility are also used for the evaluation of other mining applications which are used in continues or dis-continued applications where the risk of fire or the respective application could present a risk in the event of an underground fire. Typical examples of underground applications containing combustible materials are as follows:

- Blast barricades
- Ventilation curtains
- Rock stabilization (Spray-on coatings)
- Spray foam applications
- Polymeric Infrastructure (Steps, Water channels, Ventilation ducts etc.)

The above large-scale tests are normally requested by the Mining Authorities to prove suitability for use once the small-scale basic fire properties have been conducted and met or satisfied the specific requirements.

Stope test

Large-scale Mine Haulage test Pipes and pipe insulations

The test is performed in **FIRELAB**'s **20 meter Corridor** (**Large-scale Mine Haulage Test**). The total length of the installation is approximately 18 meters, consisting of three standard lengths of pipes with couplings. The pipes are installed 300 mm below the roof of the test corridor while being supported with steel chains at approximately every 2 metres. The pipes are tested in a **Dry State** (Open and without any water or other contents) and the front end of the installation is blocked with mineral wool as to prevent any airflow during the initial stages of the test.

The installation is exposed to the thermal output of two air aspirated diesel burners adjusting to deliver approximately 400 kW of energy. The period of exposure is 20 minutes. A **Ventilation Fan** provides airflow of approximately 1 m/s within the tunnel and is switched on 2 minutes after ignition of the two burners. The 17 K-type **Thermocouples** (**TC's**) are located at 1 m intervals along the length of the installation against the roof of the **20 meter Corridor** test facility.

Pipe installation

Combustible Pipes and Chilled Water Pipe (CWP) Insulation are Evaluated in the 20 metre Test Corridor.

Other test methods related to the use of combustible pipes and CWP insulation in mining applications are:

- DEFSTAN (NES713- Toxicity)
- SANS 10177-9 Basic Fire Properties
- SANS 10177-10 Flame Spread
- ASTM E 662- Smoke Density
- SANS 10177-5 Combustibility

Reinforced Thermo-set Resin Pipe (RTRP)

Method to test sprinkler system piping within the protected area of water spray coverage

Test for flame spread and smoke emission

- No flame propagation should take place from the flame impingement area
- The smoke emission should not be higher than 50% obscuration during the test
- If the level of the smoke emission test is in excess of 25% obscuration, test a sample in the NBS smoke density chamber for compliance with the above.
- If flame spread occurs, a sample should be tested in accordance with SANS 10177-3, the requirement being a surface fire index of Class 2 or better with the flame spread index Class 2 or better

Test for fire resistance

At no time during or after the test should the test specimen exceed a weep or leakage rate of 5l/min/m2 at the maintained pressure of 1600kPa

Method to test general Fire protection piping not within the protected area of a sprinkler system

Test for flame spread and smoke emission

- No flame propagation should take place from the flame impingement area
- The smoke emission should not be higher than 50% obscuration during the test
- If the level of the smoke emission test is in excess of 25% obscuration, test a sample in the NBS smoke density chamber for compliance with the above.
- If flame spread occurs, a sample should be tested in accordance with SANS 10177-3, the requirement being a surface fire index of Class 2 or better with the flame spread index Class 2 or better

Test for fire resistance

At no time during or after the test should the test specimen exceed a weep or leakage rate of 5l/min/m2 at the maintained pressure of 1600kPa.

Small-Scale Mining Tests

- ASTM 662, Determination of smoke densisty
- Punking tests, Determination of Punking or Non-Punking
- SANS 10177-5, Combustibility at 750 °C
- SANS 10177-9, Basic Fire Properties
- DEFSTAN (NES713), Toxicity
- Heat contribution evaluation, Log tests

ASTM 662, Small-Scale Smoke Evaluation Tests

- The standard method used, is the American Society of Testing and Materials (ASTM) E 662-94 Standard Method, using a closed smoke chamber.
- This method provides a means for determining the *specific optical density* of the smoke generated by specimens of materials and assemblies under specified exposure conditions.

PUNKING, Evaluation protocol for the determination of Punking or Non- Punking characteristics of spray foam samples (mining)

- The possible hazards which may arise from using phenol-formaldehyde foams for thermal insulation can be evaluated by the determination of the punking properties of these foams.
- The incidence of punking is observed in some phenol-formaldehyde foams. Punking is a slow combustion or smoldering initiated by a localized application of a heat source. The propagation of the combustion of the foam continues without further heating until it is reduced to a char.
- The method used for determining the punking of foam is a means of distinguishing between punking and non-punking characteristics of a material.

SANS 10177-9 Basic Fire Properties

- The small-scale test is used to determine the burning characteristics of materials of single sheets when exposed to a luminous flame of 38 mm height.
- The standard test method that is used for small scale testing is the Underwriters Laboratory (UL) 214 test method.

DEFSTAN (NES713) Toxicity of Combustion Gases

- The toxicity of gases liberated during a fire can be an important factor for the evaluation of fire performance of materials or systems, depending on the use of the material. For materials used in mines it is a very important consideration, but for outdoor purposes it is less important.
- The current standard method for the evaluation of the toxicity of combustion gases is in accordance with the **DEFSTAN (NES 713)**. The toxicity index of a material is based on the concentration of certain specific gases, measured when one gram of material is burned down completely, in one cubic meter of air.

HEAT CONTRIBUTION, Log Tests - Small-scale determination for the effectiveness of Fire Retardant Treatment of mining timber

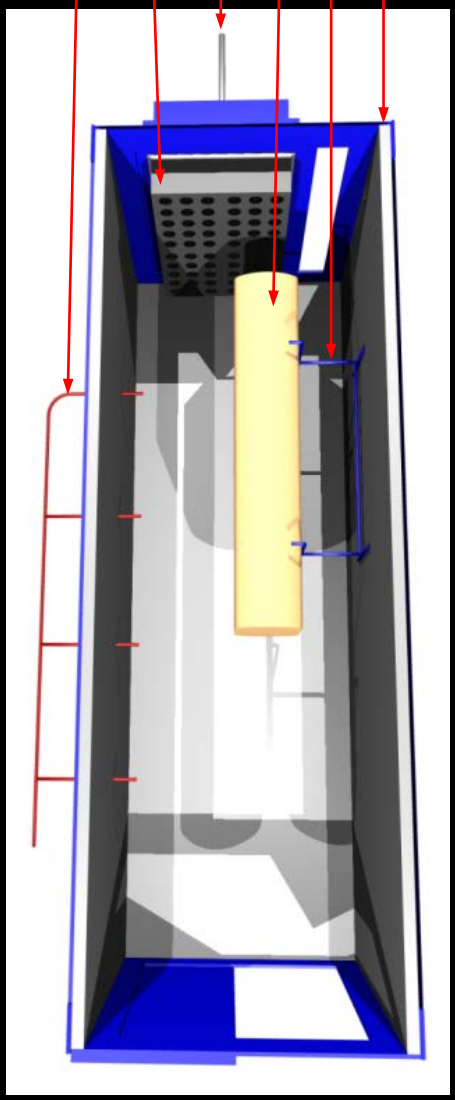
These tests are performed in the **FIRELAB** Log Furnace shown schematically in the photo below.

For these burn tests the propane burner of the furnace is adjusted until a neutral blue flame is observed. The four thermocouples in the furnace roof are connected in parallel to strip-chart recorder, which continuously registers the average temperature reading from these four thermocouples. All the thermocouples are of the K-type (Ni vs. Ni-Cr).

The furnace is preheated and allowed to reach equilibrium before a test is conducted. The equilibrium temperature is adjusted to be approximately 400 °C. The test specimen is inserted such that the one end of the log is in the flame impingement zone. The sample is removed from the furnace after 20 minutes and weighed to determine the percentage mass loss. The heat contribution of each sample is determined by measuring the area between the baseline at the equilibrium temperature and the average temperature measured by the four thermocouples in the roof of the furnace.

The heat contribution difference between the corresponding untreated and treated samples is then expressed as a percentage decrease. This value provides an indication of the effectiveness of the fire retardant treatment. A value of 50 to 60 % is normally regarded as acceptable, depending on the type of timber evaluated; in this case a 50 % decrease was deemed appropriate for the type of timber samples evaluated.

FIRELAB Small-scale Log Furnace



Note: *Enclosure size; 470 mm wide x 410 mm high x 1 200 mm lon*

A small-scale test is conducted for the evaluation of the effectiveness of fire retardant treatment of mining timber. This test is also an aid for quality control systems. The parameters measured during the small-scale test are flame spread, mass loss and heat contribution, which are directly related to surface area, moisture content and density of timber.

Apparatus

- The apparatus used for this small-scale mining timber test is a horizontal log furnace.
- The furnace is heated with a gas burner installed in the door of the furnace shown in Figure 5.1 (a) and Figure 5.1 (b).
- Four thermocouples are installed through the roof of the furnace, which are connected in parallel so as to continuously register the average temperature of the furnace during the test.
- Six thermocouples are installed through the one side wall of the furnace and connected to a data recorder. These six thermocouples register the rate of temperature rise as the fire propagates along the length of the log.

Sample preparation

- Each specimen set consists of an untreated and treated sample from the same timber pole.
- The fire retardant treated logs as well as the control sample are cut into specimens with a specific length (approx. 500 mm).
- Samples from planks are cut with length 500 mm +10 mm and width 200 mm +- 10 mm.
- The samples must be conditioned until the specimens have reached equilibrium by mass or a moisture content not exceeding 25%. The moisture content of the log is taken at a depth of 20 mm below the surface (heartwood). Every specimen to be tested is weighed prior to the test.

Method

- If specimens are tested as received, the moisture content and mass should be determined prior to the burn test.
- The four thermocouples are connected in parallel to a data recorder. – The six thermocouples through the side wall which register the temperature rises of burning logs are connected to a data recorder (if needed).
- The gas burner is adjusted to burn with a neutral flame and the furnace is preheated to reach equilibrium at a temperature of 400 +- 5° C.
- The specimen is then inserted into the furnace (on the correct tray for the respective size log) in such a way that the front end of the log is in the flame impingement zone (50 mm away from the burner).
- The test duration is 20 minutes.

Observations The following observations should be made:

- The time at which ignition of the specimen started;
- The time it takes the fire to propagate along the length of the log.
- At the end of the test period of 20 minutes, the specimen is removed from the furnace and the mass of the log recorded immediately.

Evaluation
The following information should be contained in the evaluation report:

- The percentage mass loss;
- The heat contribution (determined by measuring the area between a base line at the equilibrium temperature and the average temperature measured by the four thermocouples in the roof of the furnace).
- The heat reduction is determined by measuring the difference between the heat contributions of the control (untreated) and test specimen (treated);
- The minimum heat reduction required is given in Table 1, column 2.

Timber Lengths and Minimum Heat Reduction (HR) percentages		
Product	**Length (mm) ± 10 mm**	**Heat Reduction (HR)**
Poles	500	60 %
Pack Supports: Two sides slabbed	500	60 %
Pack Supports: Four sides slabbed	500	50 %
Elongates: Turned Unturned	 500 500	 40 % 50 %
Wedges	500	40 %
Planks	500	40 %

Minimum heat reduction for different shapes of treated wood

Results
The following test results are to be recorded:

- Time to first ignition
- Time to burn full length
- Percentage mass loss
- Total heat contribution in °C/minute
- The calculated total heat reduction in °C/minute.

Recommendations

- Tests should be repeated on a minimum of three specimen sets (control and treated) so as to get reliable results.
- As wood is a material with quite varying densities, tests should be performed on specimens with comparable densities.