Specification for 3 m Wide by 3 m High by 1.2 m Deep Vertical Fire Resistance Furnace

General

The furnace is designed to comply with the requirements in the relevant CEN,ISO and IMO standards relating to the fire resistance testing of vertical elements of construction. The equipment consists essentially of a specially designed furnace chamber onto which a restraint frame containing a specimen is positioned. The furnace is controlled to specified temperature and pressure conditions and the reaction of the specimen to the heating conditions is assessed against specified performance criteria.

The furnace will be manufactured and trial erected at the manufacturing factory and then dismantled into sections for packing into containers. On delivery it will be re-assembled and mounted onto prepared foundations.

Furnace Lining

The furnace chamber will be lined with high temperature insulating brick having a density of not more than 1000 kg/m^3 and a thickness of 100 mm. The bricks will be mechanically fixed to the structure of the furnace to prevent distortion and will be bonded together using heat resistant cement. Diatomaceous insulation will be positioned between the outer casing of the furnace and the brick lining to provide further protection to the structure of the furnace. The fire bricks and heat resistant cement will be capable of withstanding regular heating to a temperature of at least 1400°C and the insulation will be capable of maintaining its stability and thermal insulating properties after the constant heating and cooling cycles which will be experienced by the furnace.

Precast refractory blocks manufactured from dense castable material will be secured to the front edge of the base, sides and top lintel of the opening of the furnace to provide a robust and hard-wearing edging.

Four viewing ports will be positioned so that the whole of the exposed surface of the specimen can be viewed from the back of the furnace. They will be manufactured from a lightweight castable material and will be fitted with heat resistant glass, which will be capable of air cooling during tests to ensure long life and safe usage.

All materials used on the inside surfaces of the furnace will be able to withstand cyclical heating and cooling to a temperature of 1400°C and the insulation to the furnace will ensure that the outer surfaces do not exceed a temperature of 80°C.

The flue off-take containing the dampers will be lined with ceramic fibre material.

Steelwork

The outer casing of the furnace will be fabricated from structural steel sections and plates designed to form a strong and rigid construction. Steel reinforcing plates will be provided where appropriate to reinforce holes cut in the casing for burners, viewing ports, thermocouples, pressure transducers etc.

Cast Ironwork

The front outer face of the furnace will consist of specially manufactured cast iron sections bolted to the structural steelwork to provide a strong and robust mounting for the specimen restraint frames. Four specially designed roller assemblies will be cast into the sections to enable simple and fast location of a specimen restraint frame into the correct position onto the furnace by mating with wedges located on the restraint frames, the frame being securely held onto the front of the furnace by the weight of the frame and the specimen. Grooves will be incorporated into the cast iron sections to hold and retain a continuous braided ceramic fibre packing material which will form an effective seal between the restraint frame and the front face of the furnace.

Finishes

All external parts of the furnace will be painted with a high temperature paint.

Pressure Control System

Three motorised heat resisting steel dampers will be built into the extract flue to enable overall control of the pressure within the furnace chamber. Adjustable extract ports will also be provided to enable the extraction rate to be varied at different positions within the furnace chamber. The motorised steel dampers will be capable of adjustment from the designated control room via the computerised control system specified in Annex 2 or manually, as selected by the operator.

Combustion Equipment

Twelve premixed gas/air burners will be arranged in vertical banks to provide the heating to the furnace chamber. The burners will be positioned so that they produce flames which fire parallel to the face of the specimen without impinging onto the specimen. The burners will be automatically controlled to follow the relevant temperature-time heating curve by the specially designed computerised control system specified in Annex 2 or manually, as selected by the operator.

The combustion equipment will consist of:

12 - Gas nozzle mixing burners
12 - Flexible air pipes
12 - Flexible gas pipes
12 - Manual air butterfly valves
12 - Combined solenoid and restrictor valves
12 - Gas taps
12 - Low pressure gas governors, back loaded
1 - Main gas governor
3 - Main air/gas proportional opening control valves, motorised
12 - Fully automatic gas burner safety control units with integral spark ignition and ultra violet scanner
12 - Spark plugs
12 - Ultra violet type flame detectors
1 - Suction switch
2 - Gas pressure switches
1 - Set of air and gas piping
2 - Main gas shut-off valves

The burners will be suitable for use with natural or propane gas (as specified in the customer's order).

All burners will be equipped with standard safety features, including those detailed above, and will comply with the gas safety regulations in the country of use. All necessary safety requirements will be checked with the relevant authorities prior to manufacture.

The burner blocks will be manufactured from castable material comprising nominally 80% alumina and will be able to withstand the regular thermal shock associated with conducting this type of test.

Gas and Air Distribution System

Two air blowing fans will be provided to supply air to the furnace and other ancillary equipment. One of the fans will be used as a stand-by in case of break-down and to enable maintenance work to be conducted without disrupting the operations of the laboratory. The fans will be provided complete with motors and all associated electrical equipment. Options will be included for remote operation of the fans from the designated control room and for manual operation, if selected by the laboratory staff. Simple switching between fans will be possible in case of break-down.

All inter-connecting air pipework between the fans and all of the furnaces will be provided and will be in mild steel flanged lengths to assist ease of handling and to enable the sections to be bolted together on site and the pipework will be fully erected on site in positions to be agreed. Appropriate isolating dampers will be provided between the fans.

All internal gas piping will be fully erected on site in positions to be agreed, with connection to a main shut-off valve positioned at an agreed position in the laboratory. The main shut-off valve will be supplied and connected to the propane gas storage and supply system specified in Annex 2.

The gas and air distribution system will comply with all safety requirements in the country of use.

All gas and air piping will be colour coded by painting the pipework in the internationally agreed identification colours for such piping.

Extraction System and Chimney

An extraction system will be provided and will include an extract fan and flue ducting to direct extracted hot combustion gases from the furnaces during a test into the afterburner specified in Annex 3 or to the chimney, as selected by the laboratory staff.

The high-temperature extraction fan will be supplied complete with a motor and will be provided with an option for automatic starting from the control room or for manual operation, as selected by the laboratory staff.

All ducting between the extract fan and the furnace will be constructed from mild steel sections which will be supplied in suitable lengths and flanged to allow for assembly on site. The ducting will be insulated internally with stack-bonded high temperature insulation which will be sufficiently robust to withstand the regular heating and cooling cycles associated with the test. The external surfaces of the ducting will be protected from corrosion with high temperature paint.

A chimney having an internal diameter of 900 mm and a height of 12.5 metres will be provided. It will be made from mild steel and will be free-standing on a suitable foundation. The lower 3 metres will be insulated to present possible injury to staff.

Manually controlled adjustable fresh air inlet dampers will be included in the ducting at suitable locations to provide dilution of the combustion gases to reduce the temperature of the gases passing into the extract fan to below the operating temperature of the fan.

Platform/Walkway

A complete platform/walkway will be supplied which will be designed to allow safe and convenient access to the viewing ports and to all instrumentation positioned at the sides and rear of the furnace. The assembly will be provided with appropriate handrails and kickplates to ensure safe use by operators and clients. The surface of the walkway will include provision for minimising slipping of personnel using it.

Plate Thermometers

Nine plate thermometers, as specified in the relevant CEN standards will be provided and will be equally spaced over the plane of the exposed area of the specimen. The positions of the thermometers in the furnace will satisfy the requirements of the relevant CEN standards. The thermometers will be capable of being connected to the computerised data acquisition and data handling system to enable monitoring and recording of the furnace temperature before and during tests.

Furnace Thermocouples

Nine furnace thermocouples, having the specification given in the relevant IMO test method, will be provided. Provision will be made to locate them in the required positions through the rear wall of the furnace. They will be protected by appropriate heat resistant tubing to minimise distortion during tests. The thermocouples will be connected to the computerised data acquisition and data handling system to enable monitoring and recording of the furnace temperature before and during tests.

Instrumentation Connection Boxes

An instrumentation connection box will be provided in a convenient location close to the furnace, the location being shielded from heat from the furnace, to enable all instrumentation to be connected with minimum effort. The box will contain individually numbered connections which are linked by multi-core cable to correspondingly numbered connections in the designated control room which in turn will be connected to the computerised data acquisition and data handling system to enable monitoring and recording of the instrumentation before, during and after tests.

Ambient Temperature Thermometer

An ambient temperature thermometer for monitoring and recording the ambient temperature of the laboratory prior to and during tests will be provided and will be connected to the computerised data acquisition and data handling system to enable monitoring and recording of the temperature before and during tests.

Pressure Transducers

Two pressure transducers will be provided and will be located in appropriate positions to satisfy the requirements of the relevant Standards. The transducers will be moveable between positions, if required, and will be connected to the computerised data acquisition and data handling system to enable monitoring and recording of the outputs at pre-determined intervals.

Oxygen Analyser Tapping Points

Provision will be made for sampling and measuring the oxygen concentration at regular intervals during tests and calibration procedures. Appropriate permanent sampling lines and an instrumentation connection will be provided to enable a portable oxygen analyser to be connected to sample the furnace gases at appropriate positions and to be connected to the computerised data acquisition and data handling system.

Deformation Measuring Device

A device for measuring the deflection of specimens from their original position at their centre will be provided and it will comply with the requirements of the relevant CEN standards. The device will be designed to be connected to the computerised data acquisition and data handling system to enable monitoring and recording of the outputs at pre-determined intervals.

Timing Device

A timing device having a large display which can be easily seen by observers and testing staff during a test and is clearly visible on photographs of the specimen during the test will be provided. The device will be linked to the computerised control and data acquisition and data handling system to ensure that it starts at the same time as the control system. The device will be capable of displaying elapsed time to the nearest second and accurate to within 1 second in one hour.

ANNEX 2

Specification for Computerised Control and Data Monitoring and Data Handling System

The computerised control and data monitoring and data handling system is deigned to provide an efficient and reliable method of control and monitoring of the operation of the fire resistance furnace and the instrumentation attached to fire resistance test specimens. It also enables powerful computer software to conduct simple and effective data processing.

The system is designed to be user-friendly to allow relatively inexperienced test operators to conduct tests and analyse test data but also to allow full flexibility so that more experienced technical staff can analyse collected data efficiently and accurately.

Automatic Control

The system enables automatic operation of the furnace from the start of the test and automatic control of the temperature and pressure within the furnace following pre-set conditions specified by different standards and temperature-time heating curves.

The system controls the automatic ignition procedure of the burners of the furnace by optimising the rate of ignition of the burners. It regularly checks that each burner is operating and in the event of failure of any safety interlock shuts down the furnace and provides the operator with a clear warning that this has occurred.

The furnace temperature is controlled by monitoring pre-set thermocouples or plate thermometers and averaging the outputs to provide a basis for comparison with the target conditions specified in the appropriate standard. The conditions are monitored at appropriate time intervals for each test, pre-selected by the laboratory staff, and compared to the specified conditions. Adjustments to the burner settings are applied automatically to produce the required conditions. Provision is made for failed instrumentation to be omitted from the averaging calculation. Pre-set temperature-time curves are available for the relevant CEN, ISO, IMO standards and hydrocarbon curves. Provision can be made for additional curves to be added as appropriate.

During the test the display screen of the computer system provides a clear summary of the test data on a continuously updated basis. The type of information displayed at any time is selectable from pre-configured options which include the average furnace temperature, the corresponding target temperature at that time, the pressure, the elapsed time and the time of day. Graphs are available in different options and include a graph of the actual temperature and the target temperature and the actual pressure against the target pressure. Alarm conditions are communicated by visual and audible warnings. Two display screens are provided so that the basic data, such as readings from individual channels, can be displayed on one screen with alarm activation when appropriate, and graphs of the progress of the test being conducted are displayed on another screen.

Separate display screens showing the test data on a continually updated basis will be mounted at designated positions within the designated visitor observation room.

Data Acquisition and Data Analysis System

The system will have capacity to monitor approximately 50 instrumentation channels. The channels will be configured so that appropriate numbers of channels are available for the relevant types of instrumentation, such as thermocouples, pressure transducers, deflection transducers, load cells, etc.

The cabling from the furnace will pass from connection boxes positioned close to the furnace into connection boxes mounted on the walls of the control room. Each individual connection will be clearly identified with a number to assist the laboratory staff in making the appropriate connections. The connection boxes will be connected to the computer system by multi-core cable to minimise the amount of cabling within the control room.

The system will allow all pre-selected data to be displayed, together with averages of any appropriate data channels, at appropriate pre-selectable time intervals (typically every 5 seconds). The option will be available to display data as actual values or as changes from values at the start of the test. Individual channel re-scaling will be available to allow information to be displayed in appropriate units. All data will be capable of being stored on hard disk, or CD, with provision to store data for individual tests on floppy disks. A printer will also be provided to enable hard copies of selected data to be taken at pre-determined time intervals and/or at the end of tests.

Data Handling System

A comprehensive data analysis system will be provided which enables the data collected during a test to be displayed on the screen and printed in hard copy form for use in test reports. The system is versatile and enables the data to be reproduced in various forms to allow information for detailed analysis where required. Appropriate standard forms for generation of tables and graphs in standardised formats are available for day to day use when preparing standard test reports. The presentation will be of good quality and suitable for insertion into test reports without further amendment.

Facilities are available to allow conversion factors to be applied to raw data to enable conversion to standard units. Specialised appropriate requirements of standards such as calculation of areas beneath standard temperature-time curves are provided as customised procedures and where appropriate also enable the information to be presented in a standard form for inclusion in test reports.

The system will include software programmes to perform calculations specified in the relevant Standards.

Two additional separate computers will be provided and will be connected to the above laboratory computer system and will be capable of accessing the laboratory computer for test and other data. The additional computers will be located in designated areas. One of the computers will be used by the technical staff to produce tables, graphs and other data for inclusion in test reports and will incorporate the data handling software to enable this to be done. The other computer will be used to produce drawings and specifications of test specimens for inclusion in test reports and will incorporate suitable CAD software to enable the drawings to be produced by computer.

ANNEX 3

Specification for Afterburner System

A complete afterburner system will be provided which will be designed to clean smoke produced from the furnace.

The equipment will be located in a designated area on prepared foundations. The overall design of the extraction/exhaust system will enable extraction from individual items of test equipment to be directed into the chimney or through the afterburner, as selected by the laboratory staff. Provision will be made for switching between the two options at any time, including during tests.

The afterburner will be capable of heating the exhaust gases produced by the test methods so that the gases emitted from the afterburner satisfy the reasonable requirements of the local authority. A gas analysis system will be provided to measure the toxic content of the gases emitted from the afterburner and this will consist of a sampling point located in the exhaust chimney linked to analysers to enable automatic and continuous sampling of carbon monoxide, carbon dioxide, hydrogen sulphide and any other gases reasonably specified by the local authority. The analysers will be readable directly and in the designated control room. The decision to operate the afterburner will be made by the laboratory staff prior to tests based on the type of specimen to be tested. Provision will be made for automatic starting of the afterburner from the control room. The readings from the analysers will be monitored and recorded to provide records of emissions.

ANNEX 4

Specification for Non-Loadbearing Restraint Frames

Two restraint frames will be supplied for the testing of non-loadbearing specimens (by constructing specimens into the frames in a remote location from the furnace and then transporting the specimen in the frame to the furnace for the test). The frames will be constructed from substantial mild steel plates and sections to provide a strong and rigid construction which will be protected from the heat of the furnace by pre-cast high-density refractory blocks having a density between 1600 kg/m^3 and 2400 kg/m^3 and a minimum thickness of 50 mm secured to the inside face of the frame. The pre-cast blocks will include holes suitably positioned to assist with the fixing of some types of specimen and will be replaceable if damaged. The minimum internal dimensions will be 3 metres by 3 metres. The construction of the restraint frames will comply with the requirements of the relevant Standards, including the testing of bulkheads to IMO Resolution A.754 (18).

The frames will include wedges on one side that are designed to mate with the roller assemblies on the furnace cast ironwork front outer face to allow secure location of the frames onto the furnace without the need for any clamps or other similar mechanical devices. The frames will be suitable for transportation inside the laboratory by the laboratory's overhead crane which will have a capacity of 10 tonnes. The weight of each frame will not exceed 6 tonnes.

The design of the frames will ensure that the steelwork is adequately protected from the direct heat from the furnace during a test.

Supports for Restraint Frames

Two sets of free-standing supports for the non-loadbearing restraint frames will be provided.

The frames will be fabricated from structural steel members to provide a construction of the required strength and stability to allow the frames to be worked on safely. The frames will be easily movable between different locations by using the laboratory crane.

ANNEX 5

Specification for Observation Room

The specification given below has been prepared without any details being available of the construction or geometry of the laboratory in which the furnace will be located. The details will be reviewed when full details of the laboratory are available and this specification is therefore for information purposes only at this stage. The cost of the rooms will increase if additional features are required.

The observation rooms will be constructed in a position which enables the test operators and visitors to view the specimen during the test. One room will be the control room for the laboratory staff and will house the computerised control and data logging and data handling system specified in Annex 2 and the other room will be for the use of visitors witnessing tests.

The walls of the rooms will be constructed from suitable non-combustible building blocks and will contain one or more windows. Metal reflective shutters will be provided for positioning over the windows to protect them from excessive heat when certain types of specimens are tested. The roof will be constructed from concrete slabs or non-combustible building boards supported on timber ceiling joists.

A fan will be installed on the external wall of each room to enable fresh air to be drawn into the room to provide positive pressure conditions in the room to keep any smoke from the laboratory out of the room.

The dimensions of the total construction is expected to be approximately 5 metres by 2.5 metres but these dimensions will have to be reviewed when details of the laboratory building are available.

ANNEX 6

Delivery, Installation, Commissioning and Training

Delivery

All equipment will be loaded into containers and shipped to the laboratory. The customer will be responsible for off-loading and storing the equipment safely in the laboratory until the arrival of the installation engineers.

Installation

All of the equipment will be installed in agreed positions in the laboratory by our installation engineers. They will need free access to the laboratory and use of the overhead crane (when installed). Where required mobile cranes will be provided for any external installation (eg chimney, propane gas system).

Commissioning

The furnace and ancillary items will all be fully commissioned by our engineers and two separate tests will be conducted on specimens supplied and constructed by ourselves to ensure correct operation of the furnace.

Training

Up to three laboratory technical staff will be provided with training, at the same time, in conducting fire resistance tests. The trainees will spend up to two weeks at the Warrington Fire Research laboratory in the UK. The training costs are included in the price but travel and accommodation costs will be extra.

The training will include specimen preparation, conditioning requirements, conducting tests, analysing test data and reporting. Typical report formats will be provided.

ANNEX 7

Accessory Pack

An accessory pack consisting of the following items will be provided.

Plate Thermometers

10 spare plate thermometers complying with the requirements of the CEN standard will be provided.

Furnace Thermocouples

10 complete thermocouple assemblies, complete with porcelain insulators and heat resisting steel support tubes complying with the requirements of the relevant IMO and ISO standards, together with 100metres of thermocouple wire required to refurbish the thermocouple assemblies

Unexposed face thermocouples

150 disc thermocouples and 500 inorganic insulating pads (without cuts) complying with the requirements of the relevant CEN and IMO standards. The length of the thermocouple wires will be 250mm. 100 metres of blue and brown insulating sleeving to insulate the two lengths of thermocouple wires will also be provided.

Adhesive

5 kg of adhesive for bonding unexposed face thermocouples to specimens.

Internal thermocouple system

100 metres of copper/ constantan and 100 metres of chromel/ alumel thermocouple wire, together with a crimping tool or a welding system to enable internal thermocouples to be produced.

Compensating cable

2000 metres of compensating cable for use with chromel/ alumel thermocouples and 300 metres of compensating cable for use with copper/ constantan thermocouples.

Cable

500 metres of twin-core copper-wire connecting cable and 500 metres of twin-wire copper-wire connecting cable incorporating a screen to minimise electrical interference.

Connector blocks

250 electrical connector blocks to enable connection of the conducting wires of cables. The connector blocks will be capable of withstanding the temperatures which will be experienced during tests.

Roving thermocouple

Two roving thermocouples, complete with handles.

Oxygen Analyser

A portable oxygen analyser which will be compatible with the sampling points provided on the furnace and will be capable of being connected to the computerised data monitoring and data handling system specified in Annex 2.

Heat flux meter device

A device will be provided that provides a convenient and flexible system method of measuring radiation from a test specimen following the procedure specified in the relevant CEN standard. The device will be designed to enable upto three heat flux meters to be mounted on a vertical stand, with provision for the instruments to be mounted slightly off-centre to enable the position of maximum heat flux to be monitored. The device will include provision for the cables from the instruments to be protected from the radiated heat and for the instruments to be supplied with the required cooling water.

Three heat flux meters satisfying the requirements of the relevant CEN standard will be provided, together with calibration certificates in accordance with BS 6809 ‘Method for calibration of radiometers for use in fire testing’.

Cotton pad holder and pads

Two frames for supporting cotton pads as specified in the relevant standards and including a handle will be provided, together with sufficient material to produce 150 cotton pads.

ANNEX 8

Specification for Loadbearing Restraint Frame and Hydraulic Loading System

One loadbearing restraint frame will be supplied to enable loadbearing tests to be conducted. The frame will be of similar design to the non-loadbearing restraint frames but the design will be modified to enable loadbearing tests to be conducted and to withstand the increased forces experienced by the frame during such applications.

A complete hydraulic loading system will be supplied to enable loads to be applied to specimens measuring up to 3 metres by 3 metres. If appropriate the loading system will be designed to apply different ranges of load using different equipment. The capacity of the loading system will be sufficient to enable loads which may reasonably be expected to be applied. The supplier will detail the loads which can be applied.

Provision will be made to monitor and record the applied load during tests at pre-determined intervals by connecting the system to the computerised data monitoring and data handling system.

Support for Restraint Frame

A set of free-standing supports for the loadbearing restraint frame will be provided.

The frame will be fabricated from structural steel members to provide a construction of the required strength and stability to allow the frames to be worked on safely. The frames will be easily movable between different locations by using the laboratory crane.