May 2, 2004

Mr. Lim Chee Peng[1]
PSB Corporation
1 Science Park Drive
Singapore 118221

RE: Evaluation of a Comparison of ASTM 119 on steel to BS 476 Pt 20/21/22

Dear Mr. Lim Chee Peng,

This letter is in response to a recent request by Mr. John Schwartz of Contego International, Inc.[2]. It is our understanding that the British standards are specified on a project in Singapore and that the ASTM International standards are unfamiliar to Singapore authorities.

Scope of the Evaluation

- It is Omega Point Laboratories' (OPL) understanding that Contego International requests an evaluation that is based on a comparison of ASTM E 119 to BS 476 Parts 20, 21, and 22, which Contego believes are related to the OPL steel column testing of Contego's Latex Intumescent.

- This letter is based on comparing testing of steel columns to the relevant parts of BS 476 and ASTM E 119. Column testing of spray applied intumescent materials cannot be applied to beams, wall or floor constructions because the test specimen's fire exposure and fire performance may not be the same.

- Contego International is an OPL testing client but not an OPL Listing and Follow-up Service client, which means we do not have any Listings for Contego's Latex Intumescent contained in our *Directory of Listed Building Products, Materials and Assemblies.* Therefore, this letter is not to be used as justification for any other opinion or used for any other project, without the express written consent of Omega Point Laboratories. This letter will serve as Omega Point Laboratories' opinion comparing the two standards based on steel column testing. It does not address specifics of

[1] Tel: (65) 6881263, Fax: (65) 67759725, Email: chee-peng.lim@psbcorp.com
[2] P.O. Box 49, Rochester, IN 46975

the product, including traceability of test samples and installation, or actual test data generated.

Information Reviewed for Evaluation

The following documents were used for this evaluation:

- BS 476-20:1987 *Fire tests on building materials and structures. Method for determination of the fire resistance of elements of construction (general principles).*
- BS 476-21:1987 *Fire tests on building materials and structures. Method for determination of the fire resistance of loadbearing elements of construction.*
- BS 476-22:1987 *Fire tests on building materials and structures. Method for determination of the fire resistance of non-loadbearing elements of construction.*
- ASTM E 119, *Standard Test Methods for Fire Tests of Building Construction and Materials*
- ASTM STP 1163, *Fire Standards in the International Marketplace*

Comparing Test Requirements to Test Specimen Construction

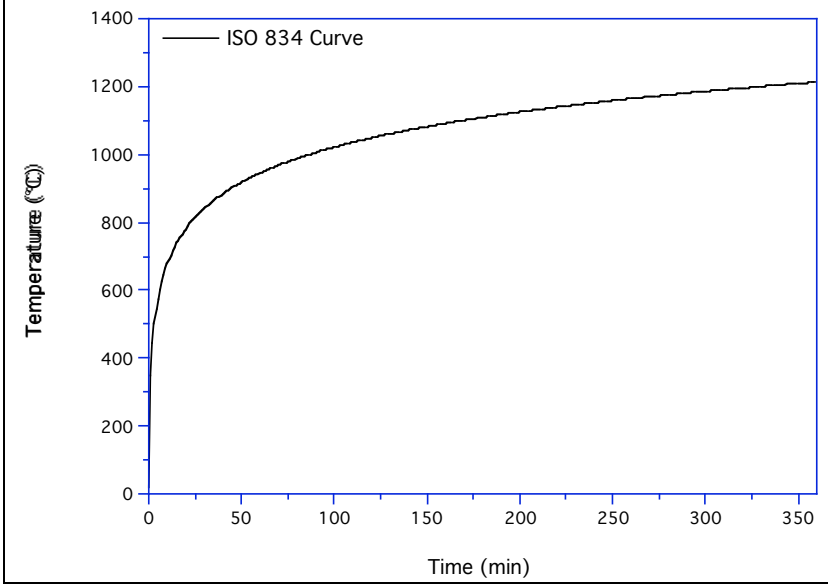
Introduction – Test Method E 119 is a complete stand-alone document that includes all of the provisions of the individual parts of BS 476 referenced above. BS 476-22 is not related to testing steel columns but rather non-loadbearig elements and is not addressed further herein. The procedures described in Test Method E119 are applicable to assemblies of masonry units and to composite assemblies of structural materials for buildings, including bearing and other walls and partitions, columns, girders, beams, slabs, and composite slab and beam assemblies for floors and roofs. They are also applicable to other assemblies and structural units that constitute permanent integral parts of a finished building. Test Method E 119 provides the following information: measurement of the transmission of heat, measurement of the transmission of hot gases through the assembly, which are sufficient to ignite cotton waste, and for individual load bearing assemblies such as beams and columns: measurement of the load carrying ability under the test exposure with consideration for the end support conditions (that is, restrained or not restrained).

The key elements of the standards are as follows:

Test conditions – The following test conditions are the same for both BS 476-20 and ASTM E 119 standards: fire exposure tolerances, uniformity of temperature distribution, and ambient laboratory conditions.

Heating conditions –The fire exposure of both BS 476-20 and ASTM E 119 standards is based on time-temperature curves. The temperatures measured when using a standard time-temperature curve (heating conditions) are dependent upon the thermocouples used. Please reference Figure 1 for the BS time-temperature curve, which is the same as the ISO 834 time-temperature curve, and Figure 2 for the ASTM time-temperature curve.

Just looking at the temperatures in Figures 1 and 2 would mislead someone into thinking that the ISO time-temperature curve is more severe. However, as previously stated many factors must be considered to determine the most severe fire exposure (heating conditions).

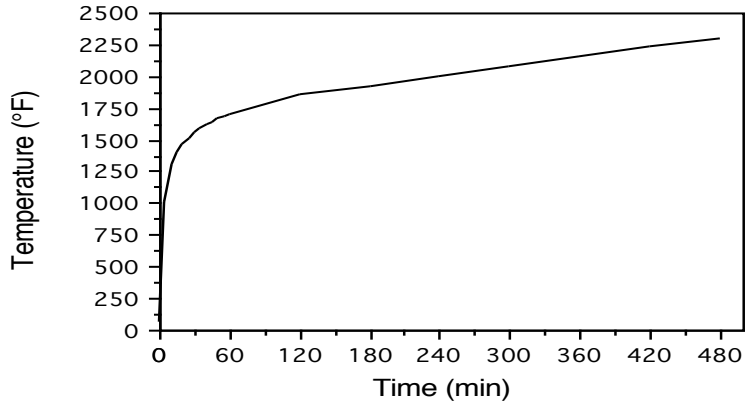


Time (min)	Temperature (°F)
0	68
5	1069
10	1254
15	1360
30	1546
60	1733
90	1843
120	1920
180	2030
240	2107
360	2215

Figure 1

That work was actually done and published in a paper titled, *Comparison of Severity of Exposure in ASTM E 119 and ISO 834 Fire Resistance Tests*[3]. When all the pertinent factors were considered the following conclusion was made: "Tests were conducted to compare fire severities arising in tests conducted in accordance with ASTM E 119 and ISO 834 specifications for measuring and controlling the nominal furnace temperature. It has been found that in fire tests of shorter duration (up to about 1.5 h) the ASTM test is slightly more severe than the ISO test. In longer tests the difference in severities is negligible."

[3] T. Z. Harmathy, M. A. Sultan and J. W. McLaurin, *Journal of Testing and Evaluation*, November 1987



Time (min)	Temperature (°F)
0	68
5	1000
10	1300
20	1462
30	1550
60	1700
90	1792
120	1850
180	1925
240	2000
300	2075
360	2150

Figure 2

Unexposed surface temperatures – BS 476-20 unexposed thermocouples, which are the same as those of ISO 834, and ASTM E 119 use different thermocouples and pads to measure the unexposed surface temperatures of test specimens. The BS 476-20 thermocouple is a copper disc and its insulating pad is thin as described in Figure 3. The ASTM thermocouple is a wire that is not heavier than No. 18 B & S gage (1.02 mm) and shall be electrically insulated with heat-resistant and moisture-resistant coatings equipped with a thermojunction. The thermojunction is usually centered under and covered by the pad. However, there are no pads used in column testing because the thermocouples are under the applied fire resistant material. The pad shall be a 150.8 ± 1 mm square with a thickness of 10 ± 1 mm and having a density of 500 ± 10 kg/m^3. Again, the issue is which method is more severe.

Recently, OPL has been comparing BS (ISO) and ASTM thermocouples and pads in ISMA tests. For example, when both types of thermocouples are placed on concrete the data indicates that during the first hour of the fire test the difference in temperatures recorded by the thermocouples is negligible. However, after 2 hours the temperature difference is quite evident, in some cases as much as 130°F. The BS thermocouples are reading much lower temperatures than the ASTM E 119 thermocouples. A comparative study of the ASTM thermocouples and pads were part of a paper titled *Fire Resistive Joints - A History in the Making*[4], which also supports the fact that thermocouple pad size and

[4] J. Nicholas, ASTM STP 1163, *Fire Standards in the International Marketplace*, 1995

thickness is another critical factor in temperature measurement. The information contained in our recent tests concluded that the ASTM thermocouples and pads are more severe based on comparative tests on various materials.

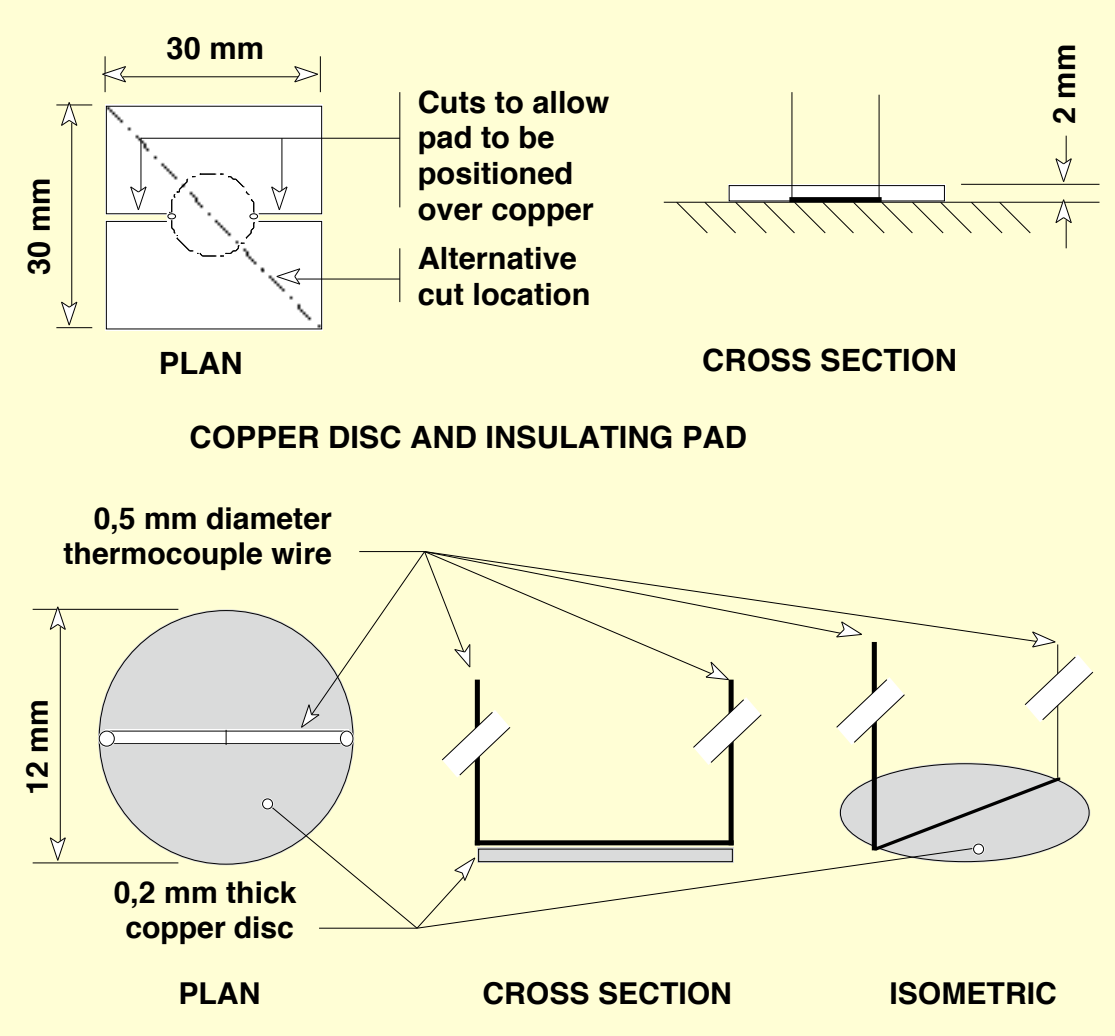


Figure 3

Test specimen – Both BS 476-20 and ASTM E 119 standards require the test specimen to be identical to or representative of that used in practice. Test specimens are tested full scale except when that size is impractical in which case both BS 476-20 and ASTM E 119 standards have established minimum sizes. The minimum size of the test specimen can be slightly different between the BS 476-20 and ASTM E 119 standards because ASTM E 119 is based on the inch-pound units and BS 476-20 is based on SI units. These differences are not critical when fire testing these large-scale test specimens. Reference Table 1 below for some comparisons.

Table 1 – Minimum Test Specimen Sizes

Element Type	Orientation	BS 476-20	ASTM E 119
Non-separating Elements (e.g. Columns)	Vertical	3 m high	8 ft (2.4 m)
Non-separating Elements (e.g. Beams)	Horizontal	4 m span	12 ft (3.7 m)
Separating Elements (e.g. Walls)	Vertical	3 m high by 3 m wide	100 ft^2 (9m^2) with neither dimension less than 9 ft (2.7 m).
Separating Elements (e.g. Floors)	Horizontal	4 m span by 3 m wide	180 ft^2 (16 m^2) with neither dimension less than 12 ft (3.7 m)

Furnace –BS 476-20 requires specific dimensions for the horizontal and vertical furnaces. ASTM E 119 requires the furnace dimensions to accommodate the various test specimen sizes referenced by the Test Method. *Note – OPL's full-scale horizontal and vertical furnaces comply with the BS 476-20 requirements.*

Pressure – BS 476-20 states that the maximum pressure to the underside of a horizontal or at the top of a vertical test construction shall not exceed 20 Pa (0.08 in. H_20). ASTM E 119 does not specify a pressure. Floor and wall test constructions that are not hermitically sealed (airtight) have one side exposed to the fire and the heat is driven to the unexposed side, therefore the furnace pressure may affect the fire performance of these items. However, columns are engulfed in fire. Therefore, the pressure is not a performance factor.

Load – BS 476-21 Section 6 (*Determination of the fire resistance of columns*) states that the column shall be tested under load. ASTM E 119 offers two alternatives. One is to expose the column to fire on all sides throughout the fire endurance test, and load it with a superimposed load to simulate a maximum load condition. This load shall be the maximum load condition allowed under nationally recognized structural design criteria unless limited design criteria are specified and a corresponding reduced load is applied. Make provision for transmitting the load to the exposed portion of the column without

increasing the effective column length. The other alternative is a test procedure that is used to evaluate the protection of steel columns without application of design load, provided that the protection material is not required by design to function structurally in resisting loads. The test specimen is exposed throughout the fire endurance test to fire on all sides for its full length. The test is regarded as successful if the transmission of heat through the protection during the period of fire exposure for which classification is desired does not raise the average (arithmetical) temperature of the steel at any one of the four levels above 1000°F (538°C), and does not raise the temperature above 1200°F (649°C) at any one of the measured points. The protected steel temperature rises are conservative in terms of steel's loss of strength at elevated temperatures. Testing to these temperature limitations would be considered a worst-case test scenario when compared to testing under load.

Based on the information contained and referenced herein, it is Omega Point Laboratories' professional judgment based on sound engineering principles that the following is true:

- *The ASTM E 119 requirements for testing a steel column are equal to or more severe than the BS 476:20 and BS 476:21 for steel columns.*

Should you need anything further or have any questions or comments, please call us at (800) 966-5253.

Sincerely,

John D. Nicholas
Director, Listing and Labeling

cc: John Schwartz, Contego International
Deggary N. Priest, President (OPL)
William E. Fitch P.E., Executive Vice President and Chief Engineer (OPL)