Assessment Report on

Compliance with NFPA 130 and BSS 7239

for Model “XNV-6022RM”

Certificate Number: IB19045
Date Issued: February 15, 2019
Date Revised: April 1, 2019

Issued for:
HANWHA TECHWIN CO., LTD.
6, Pangyo-ro 319 beon-gil, Bundang-gu, Seongnam-si,
Gyoenggi-do, 13488 Korea



Reported by:
Chemitox, Inc.
1-14-18 Kamiikedai, Ohta-ku,
Tokyo 145-0064 Japan

Hiroaki Fujioka / Vice President

1. Objective

To assess the compliance with the series of standards NFPA 130 and BSS 7239 for a product designed by the manufacturer, HANWHA TECHWIN CO., LTD. The assessment was conducted based on the information provided by the manufacturer.

2. Client Information

Company Name:	HANWHA TECHWIN CO., LTD.
Company Address:	6, Pangyo-ro 319 beon-gil, Bundang-gu, Seongnam-si, Gyoenggi-do, 13488 Korea

3. Reference Standard

NFPA 130 – Standard for Fixed Guideway Transit and Passenger Rail Systems
ASTM E162 – Standard Test Method for Surface Flammability of Materials Using a Radiant Heat Energy Source
ASTM E662 – Standard Test Method for Specific Optical Density of Smoke Generated by Solid Materials
BSS 7239 – Test Method for Toxic Gas Generation by Materials on Combustion
IEEE 1202 – IEEE Standard for Flame-Propagation Testing of Wire & Cable
ANSI/UL 1685 – Standard for Vertical-Tray Fire-Propagation and Smoke-Release Test for Electrical and Optical-Fiber Cables

4. Product Information

The product under assessment is a network camera designated "**XNV-6022RM**". This product is made by **HANWHA TECHWIN CO., LTD**.
These products are developed and designed for application in rolling stock. The enclosure (top and bottom cover) is made of aluminum parts. The dome cover consists of a transparent polycarbonate. The product contain the following functional components including printed circuit boards, and other miscellaneous materials inside the enclosure. They also have one cable assembly for communication.
The overall dimension of the products is **100mm x 98.9mm with 52mm height**.
The total mass of the products is **299.9g**.
This product will be installed on the ceiling of rolling stocks. Only the front face will be exposed to a passenger area. While multiple number of the products can be used in one vehicle, each product will be installed separately.

The diagram of "**XNV-6022RM**" is shown in **Figure 1**. The breakdown structure of the product with the part list is shown in **Figure 2**. The part list with the information of each mass is shown in **Table 1**.

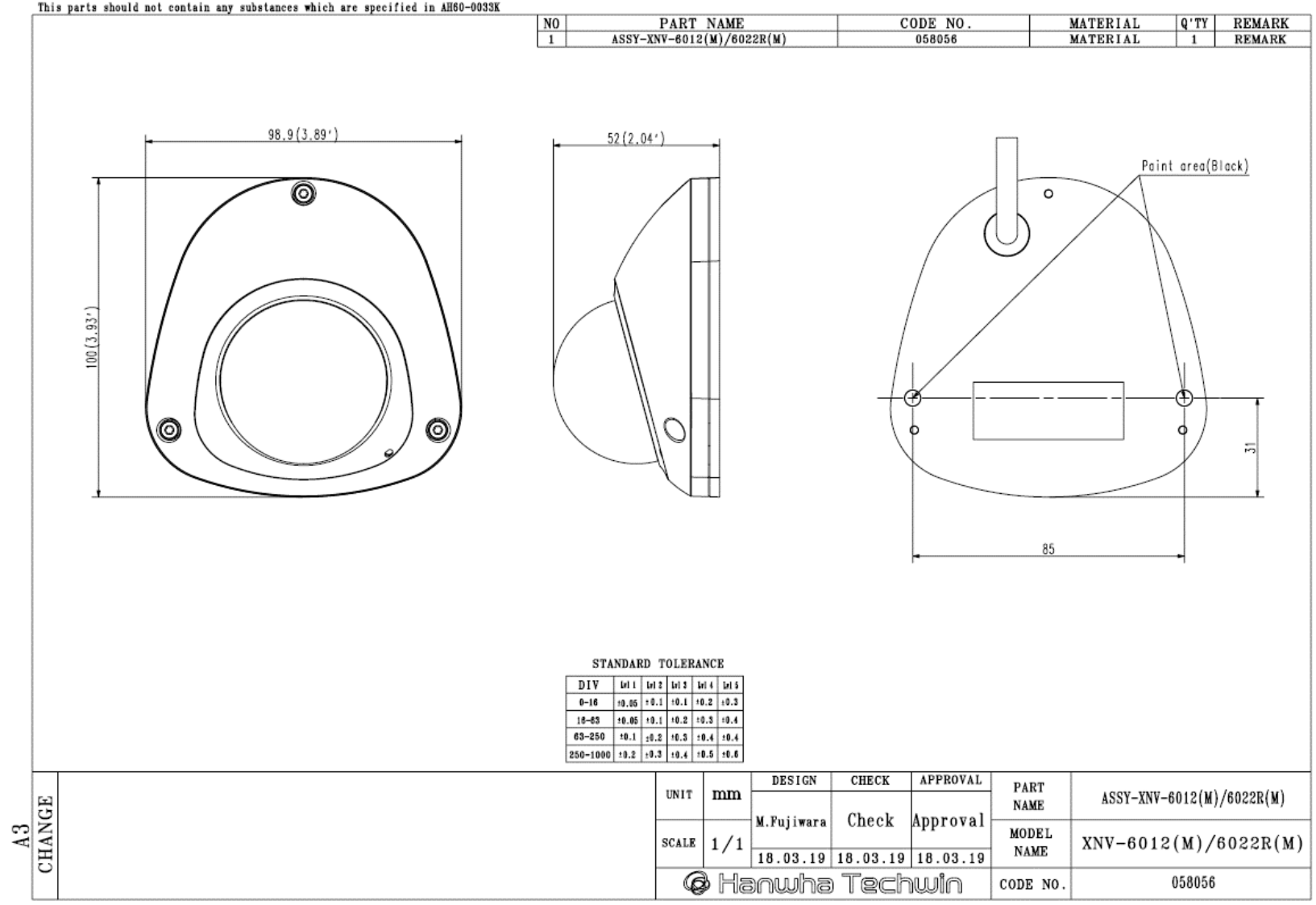
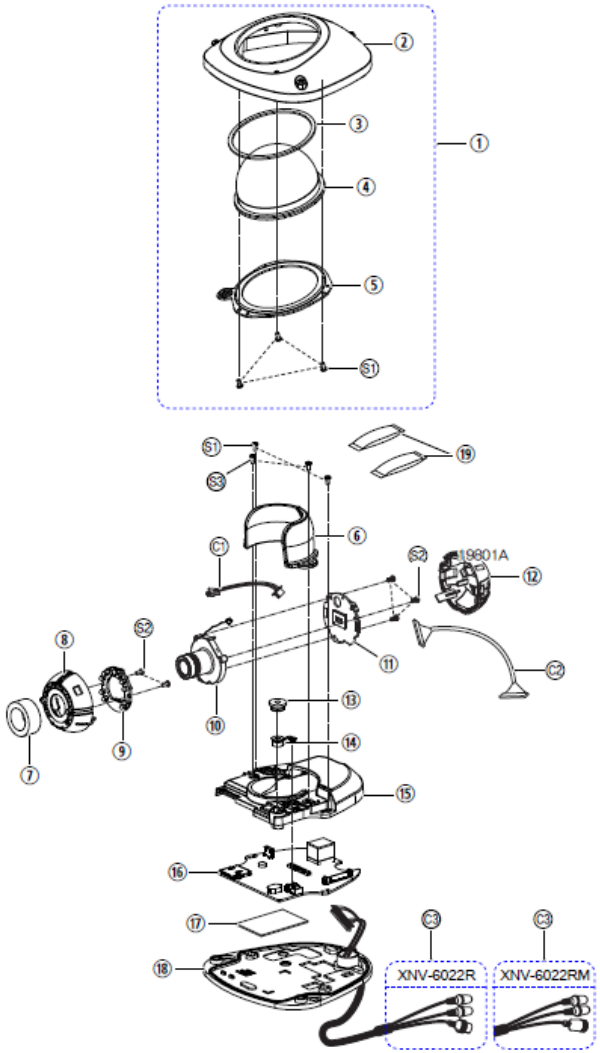


Figure 1: Diagram of "XNV-6022RM"

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Loc. No	Parts No.	Description	Specification	Q'ty	Availability	Remark
1	AM07-007536D	ASSY,CASE-TOP-WISENET,SNV-L6014RM	Logo: WISENET	1	SA	
2	FC29-007846D	CASE-TOP-WISENET,SNV-L6014RM;ADC12	Logo: WISENET	1	SA	
3	HP07-000254A	GASKET-DOME;SILICON,SNV-6013,GRAY		1	SA	
4	FC15-002790B	COVER-DOME;PC V2,MIGRATION,TRP,OD52		1	SA	
5	FC09-007358A	BRACKET-DOME,SNV-L6014RM;SECC		1	SA	
6	FC09-007359B	BRACKET-MODULE-FIXED		1	SA	
7	FC29-007945A	HOOD-IR-SNV-L6014RM		1	SA	
8	FC29-007844A	HOLDER-MODULE-TOP,SNV-L6014RM		1	SA	
9	AM06-006919A	ASSY,PCB-SNV-L6013R/L6014RM_LED_CYBRIGH		1	SA	
10	AM07-008140A	ASSY,DN MODULE-DC,SNV-L6014RM,EXPORT		1	SA	
11	AM06-007803A	ASSY,PCB-XNV-6013M(SENSOR)		1	SA	
12	FC29-007845A	HOLDER-MODULE-BOTTOM,SNV-L6014RM		1	SA	
13	FC15-005001A	COVER-MIC-RUBBER;SILICON RUBBER		1	SA	
14	EP10-001083A	MODULE,ELECTRON-IC-WHO6035CW-R50-A28J-510		1	SA	
15	FC39-003801A	FRAME-MAIN,SNV-L6014RM		1	SA	
16	AM06-007805A	ASSY,PCB-XNV-6012M(MAIN, INDOOR)		1	SA	
17	FC28-000731B	PAD-THERMAL;SILICON RUBBER,45*30*1.0		1	SA	
18	AM07-007681B	ASSY,CASE BOTTOM-XNV-6012		1	SA	XNV-6022R
	AM07-007537C	ASSY,CASE-BOTTOM,XNV-6012M		1	SA	XNV-6022RM
19	PM02-001973A	DESIPAK-1G;DESIPAK		2	SA	
C1	EP02-004376A	HARNESS-XNV-6013M;WIRE,4P-4P,55MM		1	SA	
C2	EP02-004377A	HARNESS-XNV-6013M;MCX,40P-40P,80MM		1	SA	
C3	EP02-004388A	HARNESS-XNV-6012;WIRE,14P-14P,580MM	RJ45	1	SA	XNV-6022R
	EP02-004380A	HARNESS-XNV-6013M;WIRE,14P-10P,580MM	M12	1	SA	XNV-6022RM
S1	Z8001055101A	SCREW-MACHINE	BH,+,M2,L4,ZP	5	SA	
S2	Z8003019801A	SCREW-TAPTYPE	BH,+,B,M2,L4	5	SA	
S3	Z8001042201A	MACHINE SCREW	WASHER HEAD,M2.6xL4	2	SA	

Figure 2: Breakdown Structure of "XNV-6022RM" with Part List

Part Number	Part Name	ea	Unit wt	Total wt	Material Type
(Part No.)	(Part Name)	(개)	(g)	(g)	
AM07-010924A	ASSY,FINAL-XNV-6012M	1		299.9	
AM06-007805A	ASSY,PCB-XNV-6012M(MAIN, INDOOR)	1	26.37	26.37	PCB
FC28-000731B	PAD-THERMAL;SILICON RUBBER,45*30*1.0	1	2.4	2.40	Rubber
AM07-007537C	ASSY,CASE-BOTTOM,XNV-6012M	1		103	Aluminum units(REF)
FC29-007843C	CASE-BOTTOM,XNV-6012M;ADC12	1	46		Aluminum
EP02-004380A	HARNESS-XNV-6013M;WIRE,14P-10P,580MM	1	57		cable(assembly)
FC39-003801A	FRAME-MAIN,SNV-L6014RM	1	14	14.00	PC
Z6001055101A	SCREW-MACHINE;6001-001707,BH,+,M2,L4,ZP	2	0.1	0.20	Steel-screw
FC29-007844A	HOLDER-MODULE-TOP,SNV-L6014RM	1	4	4.00	PC
EP02-003864A	CABLE-SNV-L6013R/L6014RM LED CABLE;4P,30	1	0.6	0.60	cable(inside)
AM06-006106A	ASSY,PCB-SNV-L6013R/L6014RM_LED	1	2.4	2.40	PCB
Z6003019801A	SCREW-TAPTYPE;6003-001440,BH,+,B,M2,L4,	2	0.1	0.20	Steel-screw
FC29-007845A	HOLDER-MODULE-BOTTOM,SNV-L6014RM	1	5	5.00	PC
Z6003019801A	SCREW-TAPTYPE;6003-001440,BH,+,B,M2,L4,	5	0.1	0.50	Steel-screw
Z6031007302A	WAVE_WASHER_H3	1	0.1	0.10	Stainless steel
FC29-007945A	HOOD-IR-SNV-L6014RM	1	0.2	0.20	PE
AM07-007678A	ASSY,DN MODULE-DC,SNV-L6014RM	1	6	6.00	Plastics(mixed)
EP14-001066	LENS SET-2M_3.6MM_CHIOPT;FIXED	1	4.9	4.90	Glass
AM06-007803A	ASSY,PCB-XNV-6013M(SENSOR)	1	4.1	4.10	PCB
EP02-004377A	HARNESS-XNV-6013M;MCX,40P-40P,80MM	1	1.2	1.20	cable(inside)
EP10-001083A	MODULE,ELECTRONIC-WHO6035CW-R50-A28J-510	1	0.3	0.30	Steel-speaker
FC15-005001A	COVER-MIC-RUBBER;SILICON RUBBER	1	0.2	0.20	Rubber
FC09-007359B	BRACKET-MODULE-FIXED,XNV-6013M;PC	1	5.6	5.60	PC
Z6001042201A	MACHINE SCREW(이붙이WASHER HEAD,M2.6xL4)	2	0.3	0.60	Steel-screw
AM07-007536D	ASSY,CASE-TOP-WISENET,SNV-L6014RM	1		114.9	Aluminum
FC29-007846A	CASE-TOP,SNV-L6014RM;ADC12	1	90		Aluminum
FC15-002790B	COVER-DOME;PC V2,MIGRATION,TRP,OD52	1	14		PC
HP07-000254A	GASKET-DOME;SILICON,SNV-6013,GRAY	1	0		Rubber
FC09-007358A	BRACKET-DOME,SNV-L6014RM;SECC	1	9.8		Steel
FC36-001063A	SHEET-GORE-VE90308-3.6X7.6	1	0.1		Tape
Z6001055101A	SCREW-MACHINE;6001-001707,BH,+,M2,L4,ZP	3	0.1		Steel-screw
FC18-001418A	SCREW-SPECIAL_TORX10_M3_L8;TORX,BH,FP,M3	3	0.2		Steel-screw
HP07-001123A	GASKET-TOP,SNV-L6014RM;SILICON RUBBER	1	0.1		Rubber
PM02-001973A	DESIPAK-1G;DESIPAK	2	1.4	2.80	
Z6803211501A	TAPE_1425	2	0.1	0.20	Tape
PT03-000147J	LABEL-RATING,NW3,UL-A130	1	0.1	0.10	Label

Table 1: Part List of “XNV-6022RM” with Information of Each Mass

This product establishes a network connection through the cable assembly shown in **Figure 3**.

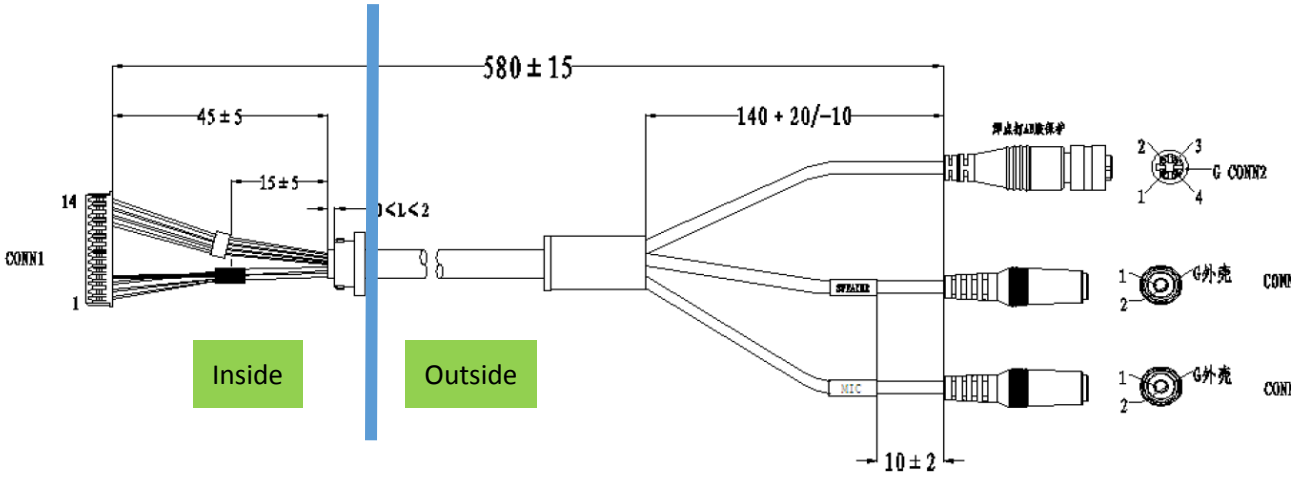


Figure 3: Detail of Cable Assembly

5. Assessment

In accordance with Chapter 8 of NFPA 130 ("Vehicles"), assessment was conducted to determine which parts/materials should be subject to flammability testing, what kind of testing should be done for each part/material, and whether the test results pass the criteria stipulated by the standard.

1) Dome Cover:

Dome cover is made of polycarbonate (HF1130R/SABIC), which is combustible, and therefore should be assessed.

Although NFPA 130 does not specify any requirement for this kind of part, the application can be considered as equivalent to "Light diffuser", because the product will be installed on the ceiling, and the dome cover part is made of transparent plastic. According to Table 8.4.1 of NFPA 130, ASTM E162 (Surface flammability testing) and ASTM E662 (smoke emission testing) were selected to demonstrate the compliance with the standard requirement. Refer to the following extract from the standard;

Light diffusers, windows, and transparent plastic windscreens[b,i]	ASTM E162	$I_s \leq 100$
	ASTM E662	D_s (1.5) ≤ 100 D_s (4.0) ≤ 200

Also, based on the general practice in the North-American railway industry, toxicity testing was conducted in accordance with **BSS 7239** in addition to the surface flammability (ASTM E162) and smoke emission (ASTM E662) testing. The typical practice in the aircraft industry was used as the criteria of toxicity.

Refer to the following table;

Table 2: Measured gas types and typical acceptance criteria

Gas Type	Acceptance Criteria
CO	≤ 3500 ppm
HCN	≤ 150 ppm
HF	≤ 200 ppm
HCl	≤ 500 ppm
SO2	≤ 100 ppm
NO2	≤ 100 ppm

The test results are summarized in **Table 3**. For more detail, refer to the test reports issued by Chemitox, SGS Govmark and Herb Curry, all of which are ISO 17025 accredited for the relevant testing (**Appendix 1**).

Table 3: Test results for Painting

Test Parameter	Test Results	Evaluation	Report Number
Is	5*	Compliant**	190046-RP (Chemitox)
Ds (1.5)	1 in flaming mode 0 in non-flaming mode	Compliant	3-30423-0 (SGS Govmark)
Ds (4.0)	64 in flaming mode 1 in non-flaming mode	Compliant	3-30423-0 (SGS Govmark)
Toxicity	Emission of all gases within acceptance criteria in both flaming and non-flaming mode	Compliant	IB19010 (Herb Curry)

*: Per the client's request, in each testing three sheets were lined up to make the dimension required by the standard.

**: Since the specimens exhibited dripping of flaming material due to melting, no formal radiant panel index shall be reported per ASTM E162 Clause 11.11, and the Is value is only for reference purpose. However, according to the footnotes relevant to the product category of light diffuser, such a behavior is considered acceptable only for this category.

Therefore, the material used for the dome cover is considered as complying with the requirements of NFPA 130.

2) Coating of aluminum enclosure:

The outer cover and cabinet are coated by certain organic painting. See **Table 4** for more detail;

Table 4: Detail of Painting

Part Name	CASE-TOP, SNV-L6014RM;ADC12
Specification of Aluminum Plate	Thickness: 2mm
Specification of Coating	<Under coat> 821KA-WJS-1193 (AKZO Nobel) Color: White <Top coat> 822KA-WJS-8635 (AKZO Nobel) Color: Ivory Thickness: 20-25 um in total

This part can be considered as “component box”. According to Table 8.4.1 of NFPA 130, ASTM E162 (Surface flammability testing) and ASTM E662 (smoke emission testing) were selected to demonstrate the compliance with the standard requirement. Refer to the following extract from the standard;

Table 8.4.1 Fire Test Procedures and Performance Criteria for Materials and Assemblies

Category	Function of Material	Test Method	Performance Criteria
Cushioning	All individual flexible cushioning materials used in seat cushions, mattresses, mattress pads, armrests, crash pads, and grab rail padding [a–e]	ASTM D 3675	$I_s \leq 25$
		ASTM E 662	D_s (1.5) ≤ 100 D_s (4.0) ≤ 175
Fabrics	Seat upholstery, mattress ticking and covers, curtains, draperies, window shades, and woven seat cushion suspensions[a–c, f–h]	14 CFR 25, Appendix F, Part I (vertical test)	Flame time ≤ 10 sec Burn length ≤ 6 in.
		ASTM E 662	D_s (4.0) ≤ 200
Other vehicle components	Seat and mattress frames, wall and ceiling lining and panels, seat and toilet shrouds, toilet seats, trays and other tables, partitions, shelves, opaque windscreens, combustible signage, end caps, roof housings, articulation bellows, exterior shells, nonmetallic skirts, and component boxes and covers[a,b,i–k]	ASTM E 162	$I_s \leq 35$
		ASTM E 662	D_s (1.5) ≤ 100 D_s (4.0) ≤ 200
	Thermal and acoustical insulation[a,b]	ASTM E 162	$I_s \leq 25$
		ASTM E 662	D_s (4.0) ≤ 100

Also, based on the general practice in the North-American railway industry, toxicity testing was conducted in accordance with **BSS 7239** in addition to the surface flammability (ASTM E162) and smoke emission (ASTM E662) testing. The typical practice in the aircraft industry was used as the criteria of toxicity. Refer to **Table 2**.

The test results are summarized in **Table 5**. For more detail, refer to the test reports issued by Chemitox, SGS Govmark and Herb Curry, all of which are ISO 17025 accredited for the relevant testing (**Appendix 2**).

Table 5: Test results for Painting

Test Parameter	Test Results	Evaluation	Report Number
Is	0	Compliant	190080-RP (Chemitox)
Ds (1.5)	0 in flaming mode 0 in non-flaming mode	Compliant	3-30423-0 (SGS Govmark)
Ds (4.0)	7 in flaming mode 0 in non-flaming mode	Compliant	3-30423-0 (SGS Govmark)
Toxicity	Emission of all gases within acceptance criteria in both flaming and non-flaming mode	Compliant	IB19011 (Herb Curry)

Therefore, the coating material is considered as complying with the requirements of NFPA 130.

3) Cable Assembly:

NFPA 130 requires all cables to be compliant with the following requirements;

> **8.6.7.1.1.1** All wires and cables shall comply with the FT4/ IEEE 1202 exposure requirements for cable char height and with ANSI/UL 1685 for total smoke released and peak smoke release rate.

In this project, the cable assembly was not tested because the client stated that they cannot prepare the required length of cable for both FT4/IEEE 1202 and ANSI/UL 1685. Therefore, **the compliance of the cable has NOT been demonstrated in this assessment report**.

However, there would still be a possibility that this cable can be used in railway vehicles by referring to **Clause 8.4.2 of NFPA 130**. See also the following extract from the standard;

> **8.4.2*** Materials intended for use in a limited area of the vehicle and not meeting the requirements of Table 8.4.1 shall be permitted only after an appropriate fire hazard analysis establishes, within the limits of precision, that the material produces a contribution to fire hazard equal to or less than a material meeting the appropriate criteria of Table 8.4.1, where the alternative material is used in the same location to fulfill a function similar to the candidate material.

For the product under assessment, the cable can be considered as producing very low contribution to fire hazard based on the following assumptions;

- While multiple number of the products can be used in one vehicle, each product will be installed separately.
- The total number of the products installed in a vehicle will be quite limited according to the purpose of the product's application (i.e. a specific area within railway vehicles is surveilled by one product).
- The mass of the cable assembly is very small (57g per the information in **Table 1**).
- The cable assembly itself will not be exposed to passenger area (i.e. it will be hidden behind ceiling panel).

With those taken into consideration, it is thought that there would be cases where users of the product accept the use of this cable assembly not demonstrating the compliance.

4) Other miscellaneous combustible materials:

There are other miscellaneous materials which are combustible. However, all those materials are very small (i.e. surface area less than 100cm^2), and except for the labels, are covered by the already assessed compliant parts. This means that they are considered as not critical and not likely to contributing to development of fire. For the labels, although they are exposed, the testing can be omitted by applying the following exception stated in NFPA 130;

8.4.1.9 Combustible operational and safety signage shall not be required to meet flame spread or smoke emission requirements if the combustible mass of a single sign does not exceed 500 g (1.1 lb) and the aggregate area of combustible signage does not exceed 1 ft^2 per foot of car length.

Therefore, those materials can be considered as complying with the requirement of NFPA 130 without any additional testing and evaluation, assuming an appropriate fire hazard analysis demonstrates that they will not contribute materially to fire growth in end use configuration.

6. Verification of compliance with NFPA 130 and BSS 7239

According to the assessment described in Item 5, the compliance with NFPA 130 for the relevant product has been verified **only in case where a fire hazard analysis based on actual end use application allows the cable assembly not to be evaluated**.

With regards to BSS 7239, it has been verified that the concentration of all emitted gases are within the acceptance criteria shown in **Table 2** in both flaming and non-flaming mode.

IMPORTANT NOTE: the acceptance criteria can vary depending on customers' specifications. In this report, verification has been conducted only based on the criteria typically used in the aerospace industry.

7. Assessment conducted by

Hiroaki Fujioka (Mr.) – Vice President of International Business Department
Chemitox Inc.

8. Revision History

Revision date: February 26, 2019
Content of revision: BSS 7239 has been added to the title of the report on Page 1. Verification of the test results for BSS 7239 has been added to Item 6 "Conclusion".

Revision date: April 1, 2019
Content of revision: "for Model "XNV-6022RM "" has been added to the title of the report on Page 1. The color of top coat in Table 4 has been corrected Gray to Ivory.

Validity of this assessment report:

This assessment is based on the information provided by the manufacturer at the time of work. If any of the information is changed, or there is any additional information to be assessed, re-assessment may be required.

This assessment is based on the requirements of NFPA standard at the date of the contract. If any parts in the standard are revised or amended in any way subsequent to that date, care must be taken to ensure that this assessment is not invalidated by those revisions or amendments.

The results of this assessment depend on the precision of the information provided by the manufacturer. If there is anything incorrect and/or insufficient in terms of the information which is critical for the evaluation, this assessment may be invalid.

This assessment is intended only to check the compliance with the standards for the design of the vehicles. Chemitox, Inc. shall not be liable for any damages and/or costs incurred as a result of incidents, defects or other similar situations in service whether in contract, tort (including negligence), breach of statutory duty or otherwise for any loss of profit, loss of business, loss of market, loss of contract, damage to goodwill, loss of anticipated savings, loss of revenue, loss or damage incurred as a result of third party claims or any indirect or consequential loss howsoever caused.

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Appendix 1

Test Report of Dome Cover Material

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TEST REPORT

Report Number: 190046-RP
Date of Issue: February 4, 2019

Issued for:

HANWHA TECHWIN CO., LTD.

6, Pangyo-ro 319beon-gil, Bundang-gu, Seongnam-si, Gyoenggi-do,13488, Korea

Prepared by:

Chemitox, Inc., Yamanashi Testing Center

18349, Egusa, Sutama-cho, Hokuto-shi, Yamanashi-ken 408-0103, Japan

Mitsuya Mochizuki,
Corporate Officer Technical Sales General
Manager PV Testing & Evaluation Div.

(1) Chemitox is accredited by the following agency to ISO/IEC 17025.
American Association for Laboratory Accreditation (A2LA) — Certificated No: 1136.03

(2) This TEST REPORT refers only to the sample tested, unless stated otherwise.

Chemitox

Date of Issue: February 4, 2019

HANWHA TECHWIN CO., LTD.

6, Pangyo-ro 319beon-gil, Bundang-gu,
Seongnam-si, Gyoenggi-do,13488, Korea

Radiant Panel Test Report

1. Objective

Radiant panel test is conducted on samples provided by **HANWHA TECHWIN CO., LTD.** based on ASTM E162-16 “Standard Test Method for Surface Flammability of Materials Using a Radiant Heat Energy Source” for evaluation.

2. Test Date

January 29, 2019

3. Test Specimen(s)

The following samples were received on January 15, 2019:

Materials : PC
Sample Name : HF1130R(Sabic)
Color : Clear
Sample Size : 150x150 mm*

*Per the client's request, in each testing three sheets were lined up to make the dimension required by the standard.

4. Test Condition

8℃ / 25%RH

5. Test Method and Conditioning

- Test Method: Based on ASTM E162-16 “Standard Test Method for Surface Flammability of Materials Using a Radiant Heat Energy Source” See attached Appendix.
- Sample conditioning:
  We predried specimens for 24 hours at 60°C and then conditioned to equilibrium at an ambient temperature of 23°C and a relative humidity of 50%.

6. Test Result

The following table summarizes the data obtained. See attached tables 1 through 4 for details.

Sample Name	Sample No.	Radiant Panel Index (Is)*	Average Radiant Panel Index (Is) $	Flaming running or flaming dripping [Yes/No]
HF1130R(Sabic)	1	4.7	5#	Yes
	2	4.8		Yes
	3	0.8		Yes
	4	9.4		Yes

* The flame spread index, Is, is the product of the flame spread factor, Fs, and the heat evolution factor, Q.

$ The average (Is) of the four specimens shall be rounded to the nearest multiple of five.

\# Since the specimens exhibited dripping of flaming material due to melting, no formal radiant panel index shall be reported per ASTM E162 Clause 11.11. The Is value is only for reference purpose.

7. Test Location

Chemitox, Inc., Yamanashi Facility
18349 Egusa, Sutama-cho, Hokuto-shi, Yamanashi-ken 408-0103, Japan

8. Performed by

Takemaru Kunugi, PV Testing・Material Testing & Evaluation Div. (Level 2)

9. Reviewed by

Mitsuya Mochizuki, Corporate Officer
Technical Sales General Manager PV Testing & Evaluation Div. (Level 3)

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Appendix

(8 Pages)

- Radiant Panel test results
  - Test method

Table 1 Radiant Panel test result

Sample Name:	HF1130R(Sabic)		
Sample thickness:	2mm	Material:	PC
Sample No.:	1	Color:	Clear
Sample Position:	Not applicable	Date of Test:	2019-01-29

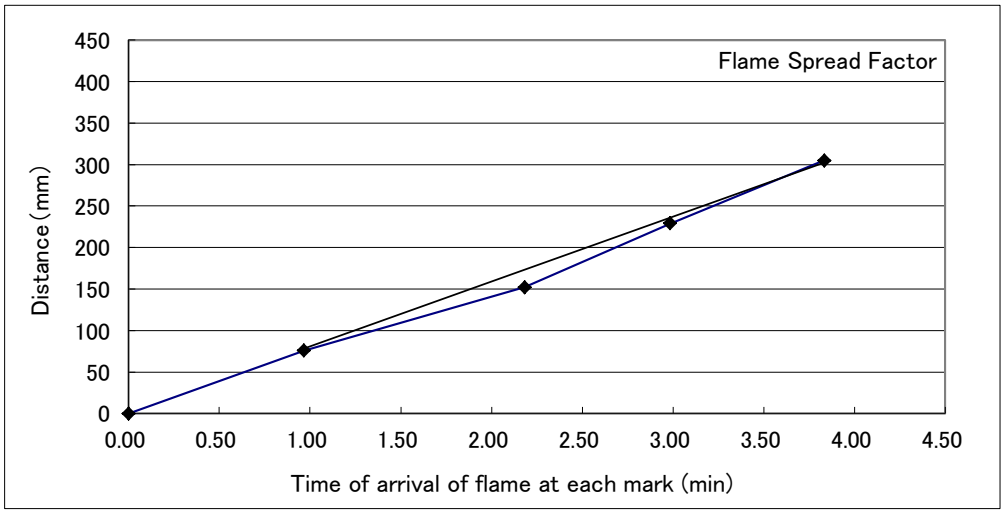
Test results:

1. Flame spread factor, Fs

	Time of arrival of flame (min)	Distance (mm)	Slope between two marks		Slope inclination Inc／Dec		Skip points K	Flame Spread Factor Fs
t_0	0.00	0	–		–			
t_3	0.97	76	$t_3 - t_0$	78.6	–	Inc		
t_6	2.18	152	$t_6 - t_3$	62.5	−16.1	Dec	9	
t_9	2.98	229	$t_9 - t_6$	96.3	33.8	Inc		
t_{12}	3.83	305	$t_{12} - t_9$	89.4	−6.9	Dec		
t_{15}	–	381	$t_{15} - t_{12}$	–	–	–		5.17

Equation to calculate the flame spread factor :

$$Fs = 1 + \quad 1/(t_3-t_0)+9/(t_{12}-t_3)$$



2. Heat evolution factor, Q

Maximum thermocouple temperarure difference between the specimen and the cement board, T (℃)	Mean thermocouple temperature rise, β (℃)	Heat Evolution Factor, Q
5.1	33.6	0.9

Equation to calculate Heat evolution factor: $Q=CT/\beta$ (C: arbitrary constant of 5.7)

3. Flame spread index, Is **4.7**

Equation to calculate Flame spread index: Is=Fs・Q

Note 1: 13mm thick millboard was used as a backing.
Note 2: Due to materials separating from the specimen holder, the specimens were retained in position by a wire mesh during testing per ASTM E162 Clause 8.8.2.
Note 3: Flaming dripping observed.
Note 4: No flashing observed.
Note 5: Per the client's request, in each testing three sheets were lined up to make the dimension required by the standard.

Table 2 Radiant Panel test result

Sample Name:	HF1130R(Sabic)		
Sample thickness:	2mm	Material:	PC
Sample No.:	2	Color:	Clear
Sample Position:	Not applicable	Date of Test:	2019-01-29

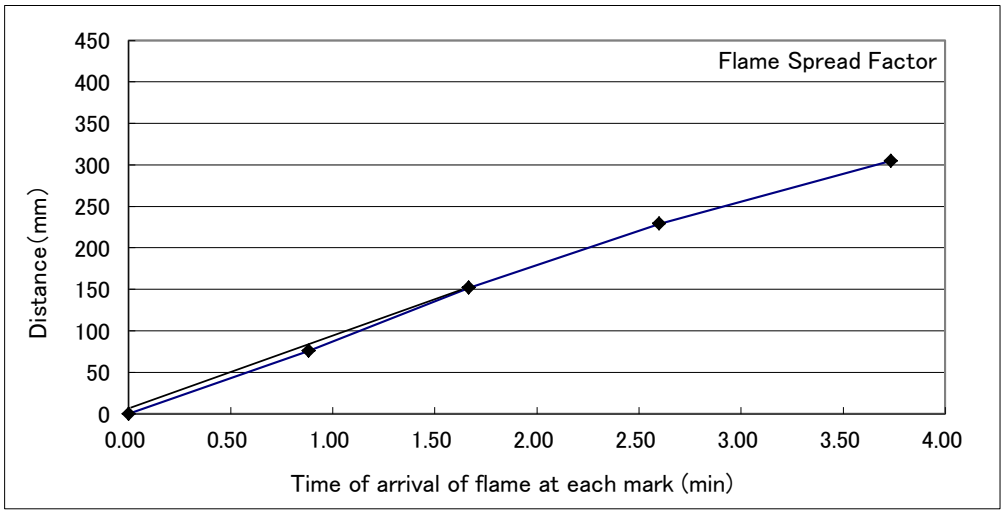
Test results:

1. Flame spread factor, Fs

	Time of arrival of flame (min)	Distance (mm)	Slope between two marks		Slope inclination	Inc／Dec	Skip points K	Flame Spread Factor Fs
t_0	0.00	0	–		–		4	
t_3	0.88	76	$t_3 - t_0$	86	–	Inc		
t_6	1.67	152	$t_6 - t_3$	97	11	Inc		
t_9	2.60	229	$t_9 - t_6$	82.5	−14.5	Dec		
t_{12}	3.73	305	$t_{12} - t_9$	67.1	−15.4	Dec		
t_{15}	–	381	$t_{15} - t_{12}$	–	–	–		5.35

Equation to calculate the flame spread factor :

$$Fs = 1 + \quad 4/(t_6-t_0)+1/(t_9-t_6)+1/(t_{12}-t_9)$$



2. Heat evolution factor, Q

Maximum thermocouple temperarure difference between the specimen and the cement board, T (℃)	Mean thermocouple temperature rise, β (℃)	Heat Evolution Factor, Q
5.3	33.6	0.9

Equation to calculate Heat evolution factor: $Q=CT/\beta$ (C: arbitrary constant of 5.7)

3. Flame spread index, Is **4.8**

Equation to calculate Flame spread index: Is=Fs・Q

Note 1: 13mm thick millboard was used as a backing.
Note 2: Due to materials separating from the specimen holder, the specimens were retained in position by a wire mesh during testing per ASTM E162 Clause 8.8.2.
Note 3: Flaming dripping observed.
Note 4: No flashing observed.
Note 5: Per the client's request, in each testing three sheets were lined up to make the dimension required by the standard.

Table 3 Radiant Panel test result

Sample Name:	HF1130R(Sabic)		
Sample thickness:	2mm	Material:	PC
Sample No.:	3	Color:	Clear
Sample Position:	Not applicable	Date of Test:	2019-01-29

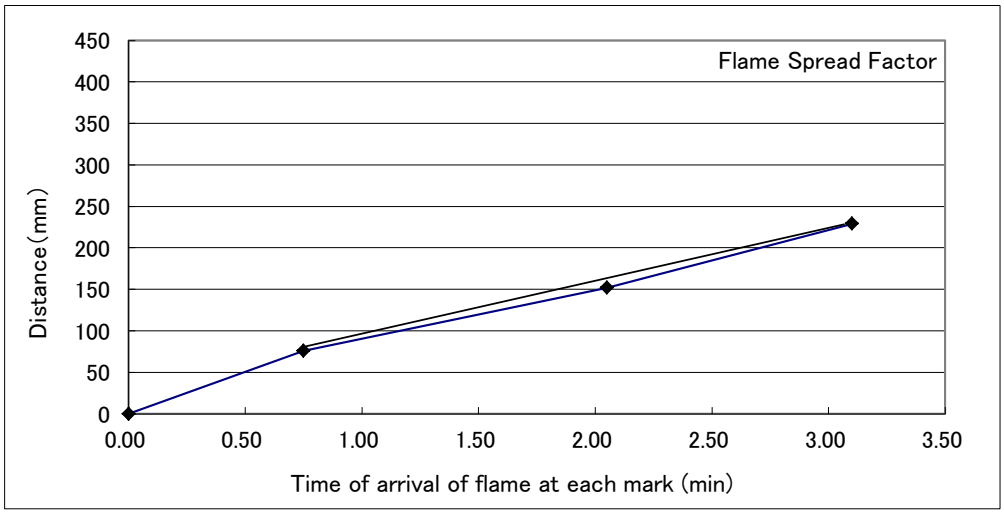
Test results:

1. Flame spread factor, Fs

	Time of arrival of flame (min)	Distance (mm)	Slope between two marks		Slope inclination Inc／Dec		Skip points K	Flame Spread Factor Fs
t_0	0.00	0	–		–			
t_3	0.75	76	$t_3 - t_0$	101.3	–	Inc	4	
t_6	2.05	152	$t_6 - t_3$	58.5	-42.8	Dec		
t_9	3.10	229	$t_9 - t_6$	73.3	14.8	Inc		
t_{12}	–	305	$t_{12} - t_9$	–	–	–		
t_{15}	–	381	$t_{15} - t_{12}$	–	–	–		4.04

Equation to calculate the flame spread factor :

$$Fs = 1 + \quad 1/(t_3-t_0)+4/(t_9-t_3)$$



2. Heat evolution factor, Q

Maximum thermocouple temperarure difference between the specimen and the cement board, T (℃)	Mean thermocouple temperature rise, β (℃)	Heat Evolution Factor, Q
1	33.6	0.2

Equation to calculate Heat evolution factor: $Q=CT/\beta$ (C: arbitrary constant of 5.7)

3. Flame spread index, Is **0.8**

Equation to calculate Flame spread index: Is=Fs･Q

Note 1: 13mm thick millboard was used as a backing.
Note 2: Due to materials separating from the specimen holder, the specimens were retained in position by a wire mesh during testing per ASTM E162 Clause 8.8.2.
Note 3: Flaming dripping observed.
Note 4: No flashing observed.
Note 5: Per the client's request, in each testing three sheets were lined up to make the dimension required by the standard.

Table 4 Radiant Panel test result

Sample Name:	HF1130R(Sabic)		
Sample thickness:	2mm	Material:	PC
Sample No.:	4	Color:	Clear
Sample Position:	Not applicable	Date of Test:	2019-01-29

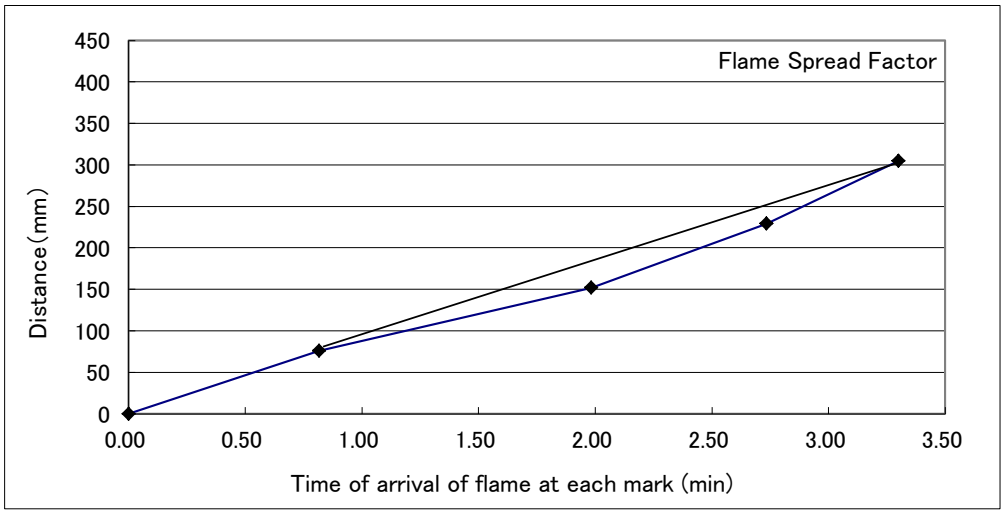
Test results:

1. Flame spread factor, Fs

	Time of arrival of flame (min)	Distance (mm)	Slope between two marks		Slope inclination Inc／Dec		Skip points K	Flame Spread Factor Fs
t_0	0.00	0	–		–			
t_3	0.82	76	$t_3 - t_0$	93.1	–	Inc		
t_6	1.98	152	$t_6 - t_3$	65.1	-28	Dec	9	
t_9	2.73	229	$t_9 - t_6$	102.7	37.6	Inc		
t_{12}	3.30	305	$t_{12} - t_9$	134.1	31.4	Inc		
t_{15}	–	381	$t_{15} - t_{12}$	–	–	–		5.85

Equation to calculate the flame spread factor :

$$Fs = 1 + 1/(t_3 - t_0) + 9/(t_{12} - t_3)$$



2. Heat evolution factor, Q

Maximum thermocouple temperarure difference between the specimen and the cement board, T (℃)	Mean thermocouple temperature rise, β (℃)	Heat Evolution Factor, Q
9.7	33.6	1.6

Equation to calculate Heat evolution factor: $Q = CT/\beta$ (C: arbitrary constant of 5.7)

3. Flame spread index, Is **9.4**

Equation to calculate Flame spread index: Is=Fs・Q

Note 1: 13mm thick millboard was used as a backing.
Note 2: Due to materials separating from the specimen holder, the specimens were retained in position by a wire mesh during testing per ASTM E162 Clause 8.8.2.
Note 3: Flaming dripping observed.
Note 4: No flashing observed.
Note 5: Per the client's request, in each testing three sheets were lined up to make the dimension required by the standard.

ASTM E162 Radiant Panel (Flame Spread) Test Method

1. Applicable Standard : ASTM E162-16 "Standard Test Method for Surface Flammability of Materials Using a Radiant Heat Energy Source"

2. Objective : To evaluate the propagation characteristics of the flame over the material surface using radiant energy and calculate the flame spread index (certain standards referencing this standard may require the radiant panel index to be at a specific value. For example, paragraph 5.4.2 of the photovoltaic module standard IEC 61730-1 requires that radiant panel index be 100 or less).

3. Sample Size : 152 x 457 mm

4. Number of Samples : Minimum of 4 per 1 specimen

5. Sample Conditioning : Preconditioned at 60℃ for 24 hours and subsequently maintained at ambient temperature 23+/-3℃, relative humidity 50%+/-5% for a minimum of 24 hours.

6. Test Procedure :

Mount the sample backed with millboard (13 mm thick) on the sample holder and begin exposure to radiation with it inclined 30 degrees from the vertically installed radiant panel. During this, the distance between the sample and the radiant panel are 121 mm at the top part and 367 mm at the bottom part.

By arranging the sample in this manner, the high radiant energy at the top part of the sample declines as it moves down towards the bottom of the sample.
The radiant panel is heated to 670℃ beforehand, and the sample is ignited with a pilot burner from the top part of the sample.
The flame ignited at the top of the sample will spread downward, but since the radiant heat gradually declines, the rate of flame spread declines. At this time, the time by which the flame spreads the sample surface is measured for every 3 inches (76 mm), and the increase of temperature inside the exhaust duct above the apparatus is measured. This procedure is repeated for a minimum of 4 times.

In addition, a standard cement board is ignited using the same procedure to measure the increase of temperature inside the exhaust duct by itself as a standard burning temperature. The radiant panel index is calculated from the resulting measurement.

7. Method of Calculation :

1) The equation for calculating the radiant panel index (Is) is as follows:

Is = Fs Q

* Fs: flame spread factor

* Q: heat evolution factor

2) The standard equation for flame spread factor (Fs) is as follows:

$$Fs = 1 + \frac{1}{t_3 - t_0} + \frac{1}{t_6 - t_3} + \frac{1}{t_9 - t_6} + \frac{1}{t_{12} - t_9} + \frac{1}{t_{15} - t_{12}}$$

* Tx: the time (in minutes) at which the measurement point (x inches) located 3 inches apart was reached.

The flame spread factor (Fs) is the number obtained by adding 1 to the sum of 1 over the difference of the time at which the measurement point was reached and the time at which the previous measurement point was reached.

Additionally, a line graph is constructed with the distance every 3 inches as the vertical axis against the time at which the flame reached each 3-inch-mark as the horizontal axis. In this graph, a straight line is drawn from the previous point to the succeeding point at segments where the slope increases; i.e. the increase is eliminated by skipping the point at which the slope increases. This process is repeated as until slope increases are eliminated. The points that remain below the curve are the "skip points".

The data for the measurement point which became a "skip point" will be omitted from the equation for flame spread factor, and only values that are not skipped will be used for this calculation.

When substituting for the above equation, for fractions that have a difference where skip points exist as the denominator, term K in the table below shall be used as the denominator, which varies with the number of "skip points":

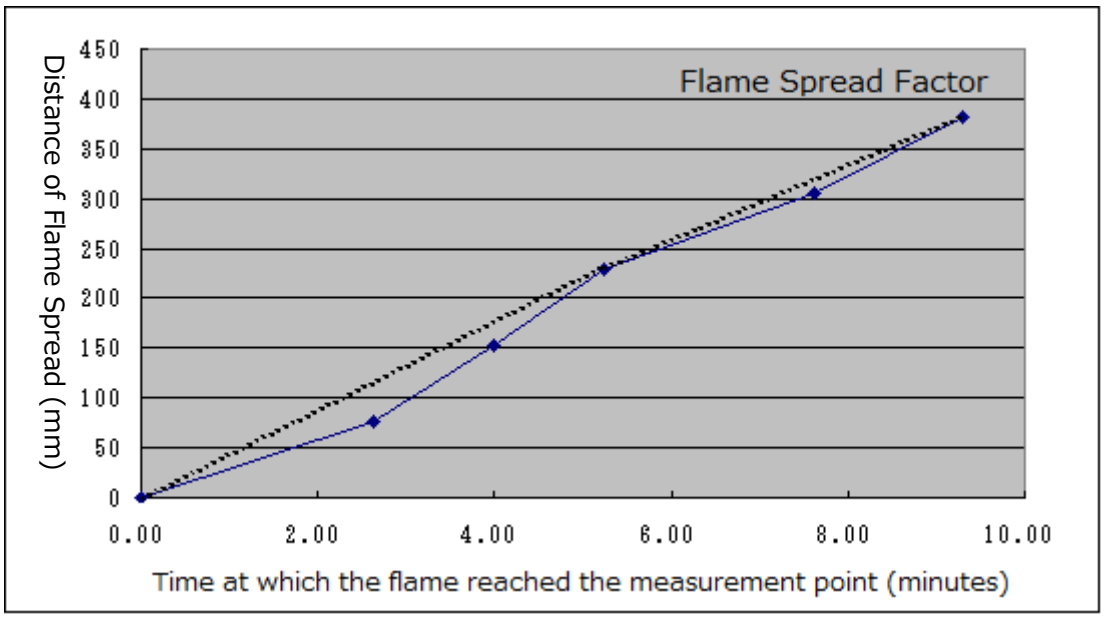
Number of skip points	K
One Single	4
Two Consecutive	9
Three Consecutive	16
Four Consecutive	25

An example of the calculation of flame spread factor with “skip points” is indicated below:

Calculation Example

Flame Spread Factor, Fs

	Time (minutes)	Distance (mm)	Slope Coefficient of Each Graph Segment		Increase/Decrease of Slope		Skip Point K	Flame Spread Factor, Fs
t_0	0.00	0	–		–			
t_3	2.63	76	$t_0 - t_3$	28.9	–	Increase		
t_6	4.00	152	$t_3 - t_6$	55.5	26.6	Increase	9	
t_9	5.23	229	$t_6 - t_9$	62.6	7.1	Increase		
t_{12}	7.63	305	$t_9 - t_{12}$	31.7	−30.9	Decrease	4	
t_{15}	9.30	381	$t_{12} - t_{15}$	45.5	13.8	Increase		3.70



From the above results,

$\frac{1}{t_3 - t_0} + \frac{1}{t_6 - t_3} + \frac{1}{t_9 - t_6}$ is replaced by $\frac{9}{t_9 - t_0}$ and

$\frac{1}{t_{12} - t_9} + \frac{1}{t_{15} - t_{12}}$ is replaced by $\frac{4}{t_{15} - t_9}$, and

the equation for flame spread factor becomes:

$$Fs = 1 + \frac{9}{t_9 - t_0} + \frac{4}{t_{15} - t_9}$$

3) The equation for heat evolution factor is as follows:

$Q = CT / \beta$

* C: constant 5.7

* T: the maximum thermocouple temperature difference (℃) in the chimney between the sample and standard cement board combustion.

* β: Mean thermocouple temperature increase in the chimney (℃/Kw), calculated during the calibration of the test apparatus.

8. Evaluation Criteria : Pass/fail is not determined by ASTM E162, and the radiant panel index is the test result. However, certain standards and company specific standards that reference the ASTM E162 require a certain value, and if this value is not satisfied, the material is determined to be nonconforming.

For Example, IEC 61730-1, Standard for Photovoltaic Module Materials, requires a radiant panel index 100 or less, and if the radiant panel index exceeds this value, it is considered not compliant.

SGS GOVMARK

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Farmingdale, New York 11735-5626 USA
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email: govmark.accounting@sgs.com

Received: 01/17/2019	Completed: 01/23/2019	Letter: Q	AM	P.O.#: IB19010	Test Report #:	3-30423-0-
Client's Identification	Composition: 2mm Thick Polycarbonate. Thickness: 2mm. Additional Information: Product Name: HF1130R (Sabic).					

Tested For: **Masao Fujiwara**
Hanwha Techwin Co., LTD
6 Pangyo-ro 319beon-gil, Bundang-gu
Seongnam-siGyoenggi-do13488Korea

Key Test: ASTM E662 12S 925

Tel: 011 8270 71475426 **Ext:**
Fax:

Category: Smoke Density Specifier: ASTM LE 2017a; V 11/17 PC: 24H+ME
CODE: 725(6S); 925(12S) SM/mg

TEST PERFORMED: ASTM E662 - Standard Test Method For Specific Optical Density of Smoke Generated by Solid Materials (NFPA Designation No. 258)

APPROXIMATE THICKNESS OF MATERIAL (as measured by SGS Govmark): 0.081"

BRIEF DESCRIPTION OF TEST: Two separate tests are conducted on three specimens. In one test, the face of each specimen is exposed to a radiant heat source of 2.5 W/cm² (non-flaming mode). In a second test, completely new specimens are subjected to both the radiant heat source and six small igniting flames (flaming mode). As smoke accumulates in the test chamber, the percent light obscuration is converted to a smoke density value. Typically, the highest value within a maximum test period of 20 minutes is recorded, along with interim value at 90 seconds and 4 minutes.

At the conclusion of the test, a minus adjustment is made (clear beam reading) for any particles deposited on the optical windows.

REMARKS: None.

-- See Page 2 for "Results" --

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SGS GOVMARK

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Farmingdale, New York 11735-5626 USA
Tel. +1 (631) 293-8944 Fax +1 (631) 293-8956
email: govmark.accounting@sgs.com

Received:01/17/2019	Completed:01/23/2019	Letter: Q	AM	P.O.#: IB19010	Test Report #: 3-30423-0-
Client's Identification	Composition: 2mm Thick Polycarbonate. Thickness: 2mm. Additional Information: Product Name: HF1130R (Sabic).				

Tested For: **Masao Fujiwara**
Hanwha Techwin Co., LTD
6 Pangyo-ro 319beon-gil, Bundang-gu
Seongnam-siGyoenggi-do13488Korea

Key Test: ASTM E662 12S 925

Tel: 011 8270 71475426 **Ext:**
Fax:

RESULTS:

	Specimen #	Flaming Mode	Non Flaming Mode
90 Seconds: Specific Optical Density	1	0	0
	2	1	0
	3	1	0
	4	1	0
	5	0	0
	6	0	0
	Avg:	1	0
4 Minutes: Specific Optical Density	1	75	1
	2	28	2
	3	90	1
	4	34	1
	5	66	1
	6	93	0
	Avg:	64	1
Within 20 Minutes: Maximum Specific Optical Density	1	96 (88)	21 (21)
	2	63 (59)	28 (28)
	3	98 (91)	21 (21)
	4	98 (94)	20 (20)
	5	90 (83)	31 (31)
	6	128 (120)	21 (21)
	Avg:	96 (89)	24 (24)

CORRECTION FACTOR: At the conclusion of each test, combustion particles are removed from the glass protecting the photodetector. The corrected value in parentheses is used to recognize what may be a change in light obscuration.

ABBREVIATION WHICH MAY BE USED: NR = Not required.

ACCEPTANCE CRITERIA: None cited.

CONCLUSION: Not applicable.

CERTIFICATION: I certify that the above results were obtained after testing specimens in accordance with the procedures and equipment specified above.

Bobby Brown

JAN 29 2018

CHEMI-JP/HANWHAT/CHEMI-JP

AUTHORIZED SIGNATURE
SGS GOVMARK
/gb /pm

The results contained in this report relate only to item(s) tested. The test report shall not be reproduced, except in full, without written approval from Govmark.

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Herb Curry, Inc.
1701 Leonard Road, PO Box 753
Mt Vernon, IN 47620

Flammability Technology Services
FAA – DER
www.herbcurryinc.com

812.838.6703 (Phone)
812.838.6712 (Fax)
burnit@evansville.net

TOXICITY CERTIFICATE
BOEING BSS 7239 Non-Flaming

Herb Curry, Inc. has been accredited to ISO/IEC 17025:2005 for testing. PJLA Accreditation #80445

REQUESTOR: Hanwha Techwin Co., LTD
6, Pangyo-ro 319beon-gil, Bundang-gu
Seongnam-si, Gyoenggi-do,
13488 Korea

PHONE: 82-70-7147-5426 DATE: 1/18/2019

Attn: Masao Fujiwara

Email: m.fujiwara@hanwha.com

Sample ID: HF1130R (SABIC)
Composition: PC plate

Thickness: 2.0 mm
PO#: IB19010
Physical Condition of Samples: Good

REFERENCE: Chamber S/N 61900, BSS 7239
Dräeger Tubes (DT), Potentiometry (PO), Gas Flue Analysis (Testo 350) (GF)

RESULTS:

GASSES	LIMITS @ 4 MIN	Non-FLAMING		P/F	Non-FLAMING		P/F	Non-FLAMING		P/F
		Result	Method		Result	Method		Result	Method	
HCN	150 PPM	<1	☒ DT	P	<1	☒ DT	P		☐ DT	
CO	3500 PPM	2	☐ DT ☒ GF	P	4	☐ DT ☒ GF	P		☐ DT ☐ GF	
NO/NO²	100 PPM	0	☐ DT ☒ GF	P	0	☐ DT ☒ GF	P		☐ DT ☐ GF	
SO²	100 PPM	2	☐ DT ☒ GF	P	2	☐ DT ☒ GF	P		☐ DT ☐ GF	
HF	100 PPM	*<1	☒ DT	P	<1	☐ PO ☒ DT	P		☐ PO ☐ DT	
HCL	150 PPM	<1	☒ DT	P	<1	☒ DT	P		☐ DT	

Note: IND. = Indeterminate. Test values exceed maximum limits of Dräger tube.
**Positive = Indicative test; HF is detected*

Tested by: Scott VanWormer **Date:** 1-18-19

Authorized by: Scott VanWormer **Position:** Vice-President

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Results contained in this report are reflective only of the items tested. The unique ID# of the test report is the test report date and unique sample ID#.

Herb Curry, Inc.
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Flammability Technology Services
FAA – DER
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TOXICITY CERTIFICATE
BOEING BSS 7239 Flaming

Herb Curry, Inc. has been accredited to ISO/IEC 17025:2005 for testing. PJLA Accreditation #80445

REQUESTOR: Hanwha Techwin Co., LTD
6, Pangyo-ro 319beon-gil, Bundang-gu
Seongnam-si, Gyoenggi-do,
13488 Korea

PHONE: 82-70-7147-5426 DATE: 1/18/2019

Attn: Masao Fujiwara

Email: m.fujiwara@hanwha.com

Sample ID HF1130R (SABIC)
Composition: PC plate

Thickness: 2.0 mm
PO#: IB19010
Physical Condition of Samples: Good

REFERENCE: Chamber S/N 61900, BSS 7239
Dräeger Tubes (DT), Potentiometry (PO), Gas Flue Analysis (Testo 350) (GF)

RESULTS:

GASSES	LIMITS @ 4 MIN	FLAMING		P/F	FLAMING		P/F	FLAMING		P/F
		Result	Method		Result	Method		Result	Method	
HCN	150 PPM	<1	☒ DT	P	<1	☒ DT	P		☐ DT	
CO	3500 PPM	351	☐ DT ☒ GF	P	371	☐ DT ☒ GF	P		☐ DT ☐ GF	
NO/NO²	100 PPM	9	☐ DT ☒ GF	P	12	☐ DT ☒ GF	P		☐ DT ☐ GF	
SO²	100 PPM	22	☐ DT ☒ GF	P	30	☐ DT ☒ GF	P		☐ DT ☐ GF	
HF	100 PPM	*<1	☒ DT	P	<1	☐ PO ☒ DT	P		☐ PO ☐ DT	
HCL	150 PPM	3	☐ DT	P	2	☒ DT	P		☐ DT	

Note: IND. = Indeterminate. Test values exceed maximum limits of Dräger tube.
**Positive = Indicative test; HF is detected*

Tested by: Scott VanWormer **Date:** 1-18-19

Authorized by: Scott VanWormer **Position:** Vice-President

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Results contained in this report are reflective only of the items tested. The unique ID# of the test report is the test report date and unique sample ID#.

Chemitox

Appendix 2

Test Report of Coating

ACCREDITED
TESTING CERT #1136.03

Chemitox

TEST REPORT

Report Number: 190080-RP
Date of Issue: February 4, 2019
Date of Revision: March 18, 2019

Issued for:

HANWHA TECHWIN CO., LTD.

6, Pangyo-ro 319beon-gil, Bundang-gu, Seongnam-si, Gyoenggi-do,13488, Korea

Prepared by:

Chemitox, Inc., Yamanashi Testing Center

18349, Egusa, Sutama-cho, Hokuto-shi, Yamanashi-ken 408-0103, Japan

Mitsuya Mochizuki,
Corporate Officer Technical Sales General
Manager PV Testing & Evaluation Div.

(1) Chemitox is accredited by the following agency to ISO/IEC 17025.
American Association for Laboratory Accreditation (A2LA) — Certificated No: 1136.03

(2) This TEST REPORT refers only to the sample tested, unless stated otherwise.

Chemitox

Date of Issue: February 4, 2019

HANWHA TECHWIN CO., LTD.

6, Pangyo-ro 319beon-gil, Bundang-gu,
Seongnam-si, Gyoenggi-do,13488, Korea

Radiant Panel Test Report

1. Objective

Radiant panel test is conducted on samples provided by HANWHA TECHWIN CO., LTD. based on ASTM E162-16 “Standard Test Method for Surface Flammability of Materials Using a Radiant Heat Energy Source” for evaluation.

2. Test Date

January 29, 2019

3. Test Specimen(s)

The following samples were received on January 17, 2019:

Product Name:	XNV-6022RM
Part List Name:	CASE-TOP, SNV-L6014RM;ADC12
Composition:	Aluminum + Coating
Under coat:	“AKZO Nobel”, 821KA-WJS-1193, white color,
Top coat:	“AKZO Nobel”, 822KA-WJS-8635, Ivory color,
Thickness:	Aluminum plate: 2mm Coating(two layers): 20~25 μm
Sample Size:	152x457 mm

4. Test Condition

8℃ / 75%RH

5. Test Method and Conditioning

- Test Method: Based on ASTM E162-16 “Standard Test Method for Surface Flammability of Materials Using a Radiant Heat Energy Source” See attached Appendix.
- Sample conditioning:
  We predried specimens for 24 hours at 60°C and then conditioned to equilibrium at an ambient temperature of 23°C and a relative humidity of 50%.

6. Test Result

The following table summarizes the data obtained. See attached tables 1 through 4 for details.

Sample Name	Sample No.	Radiant Panel Index (Is)*	Average Radiant Panel Index (Is) $	Flaming running or flaming dripping [Yes/No]
CASE-TOP, SNV-L6014RM;ADC12	1	1.0	0	No
	2	1.6		No
	3	1.3		No
	4	1.3		No

* The flame spread index, Is, is the product of the flame spread factor, Fs, and the heat evolution factor, Q.

$ The average (Is) of the four specimens shall be rounded to the nearest multiple of five.

7. Test Location

Chemitox, Inc., Yamanashi Facility
18349 Egusa, Sutama-cho, Hokuto-shi, Yamanashi-ken 408-0103, Japan

8. Performed by

Takemaru Kunugi, PV Testing・Material Testing & Evaluation Div. (Level 2)

9. Reviewed by

Mitsuya Mochizuki, Corporate Officer
Technical Sales General Manager PV Testing & Evaluation Div. (Level 3)

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Appendix

(8 Pages)

- Radiant Panel test results
  - Test method

Table 1 Radiant Panel test result

Sample Name:	CASE-TOP,SNV-L6014RM;ADC12		
Sample thickness:	2mm	Material:	Aluminum+Coating
Sample No.:	1	Color:	Ivory
Sample Position:	Not applicable	Date of Test:	2019-01-29

Test results:

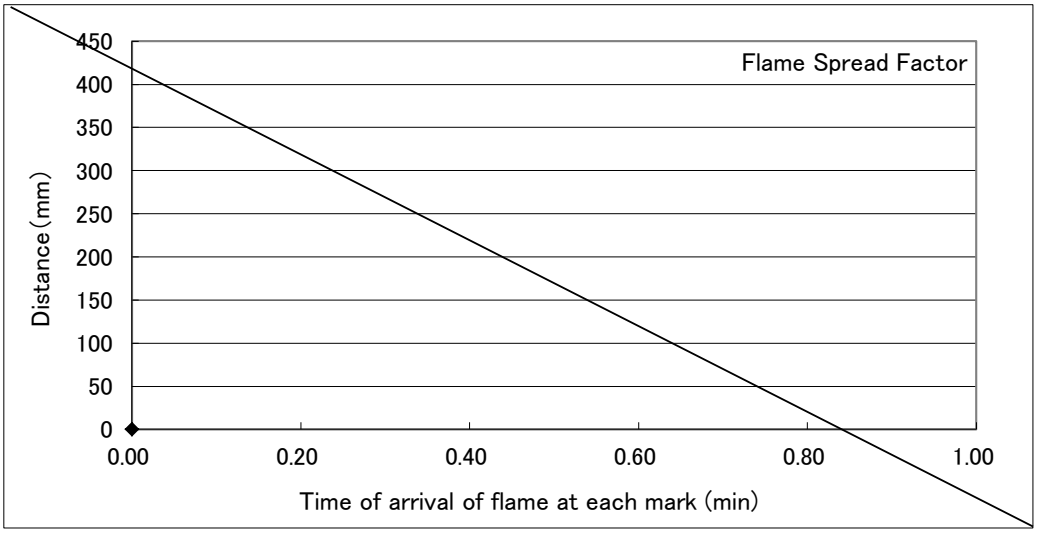
1. Flame spread factor, Fs

	Time of arrival of flame (min)	Distance (mm)	Slope between two marks		Slope inclination Inc／Dec		Skip points K	Flame Spread Factor Fs
t_0	0.00	0	–		–			
t_3	–	76	$t_3 - t_0$	–	–	–		
t_6	–	152	$t_6 - t_3$	–	–	–		
t_9	–	229	$t_9 - t_6$	–	–	–		
t_{12}	–	305	$t_{12} - t_9$	–	–	–		
t_{15}	–	381	$t_{15} - t_{12}$	–	–	–		1.00

Equation to calculate the flame spread factor :

$$Fs = 1 + \frac{1/(t_3-t_0)+1/(t_6-t_3)+1/(t_9-t_6)+1/(t_{12}-t_9)+1/(t_{15}-t_{12})}{}$$

2019-02-04 tk



2019-02-04 tk

2. Heat evolution factor, Q

Maximum thermocouple temperarure difference between the specimen and the cement board, T (℃)	Mean thermocouple temperature rise, β (℃)	Heat Evolution Factor, Q
6.1	33.6	1.0

Equation to calculate Heat evolution factor: $Q=CT/\beta$ (C: arbitrary constant of 5.7)

3. Flame spread index, Is **1.0**

Equation to calculate Flame spread index: Is=Fs・Q

Note 1: 13mm thick millboard was used as a backing.
Note 2: No Flaming dripping observed.
Note 3: No flashing observed.

190080-RP

Table 2 Radiant Panel test result

Sample Name:	CASE-TOP,SNV-L6014RM;ADC12		
Sample thickness:	2mm	Material:	Aluminum+Coating
Sample No.:	2	Color:	Ivory
Sample Position:	Not applicable	Date of Test:	2019-01-29

Test results:

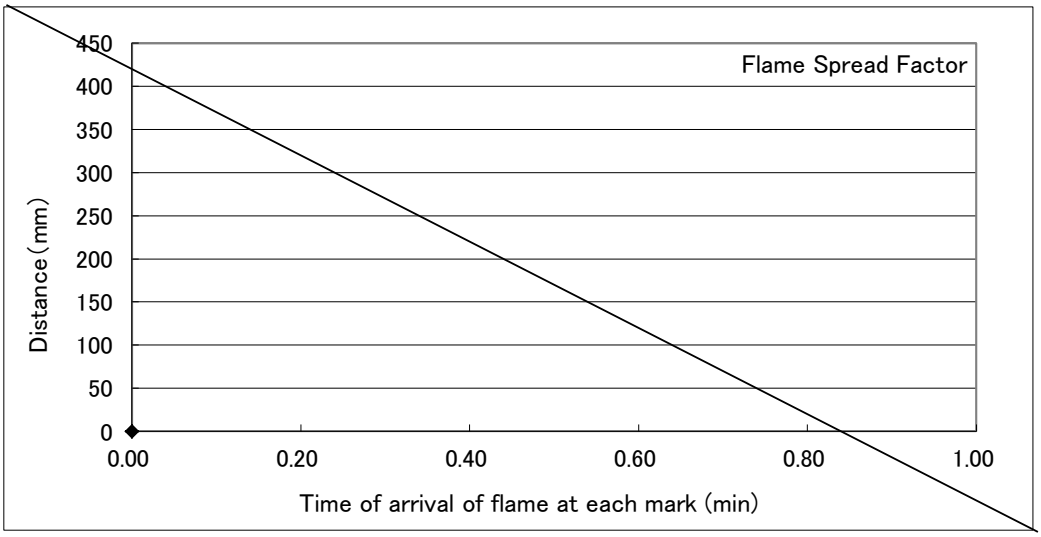
1. Flame spread factor, Fs

	Time of arrival of flame (min)	Distance (mm)	Slope between two marks		Slope inclination Inc／Dec		Skip points K	Flame Spread Factor Fs
t_0	0.00	0	–		–			
t_3	–	76	$t_3 - t_0$	–	–	–		
t_6	–	152	$t_6 - t_3$	–	–	–		
t_9	–	229	$t_9 - t_6$	–	–	–		
t_{12}	–	305	$t_{12} - t_9$	–	–	–		
t_{15}	–	381	$t_{15} - t_{12}$	–	–	–		1.00

Equation to calculate the flame spread factor :

2019-02-04 tk

$$Fs = 1 + \frac{1/(t_3 - t_0)+1/(t_6 - t_3)+1/(t_9 - t_6)+1/(t_{12} - t_9)+1/(t_{15} - t_{12})}{}$$



2019-02-04 tk

2. Heat evolution factor, Q

Maximum thermocouple temperarure difference between the specimen and the cement board, T (℃)	Mean thermocouple temperature rise, β (℃)	Heat Evolution Factor, Q
9.5	33.6	1.6

Equation to calculate Heat evolution factor: $Q=CT/\beta$ (C: arbitrary constant of 5.7)

3. Flame spread index, Is **1.6**

Equation to calculate Flame spread index: Is=Fs・Q

Note 1: 13mm thick millboard was used as a backing.
Note 2: No Flaming dripping observed.
Note 3: No flashing observed.

190080-RP

Table 3 Radiant Panel test result

Sample Name:	CASE-TOP,SNV-L6014RM;ADC12		
Sample thickness:	2mm	Material:	Aluminum+Coating
Sample No.:	3	Color:	Ivory
Sample Position:	Not applicable	Date of Test:	2019-01-29

Test results:

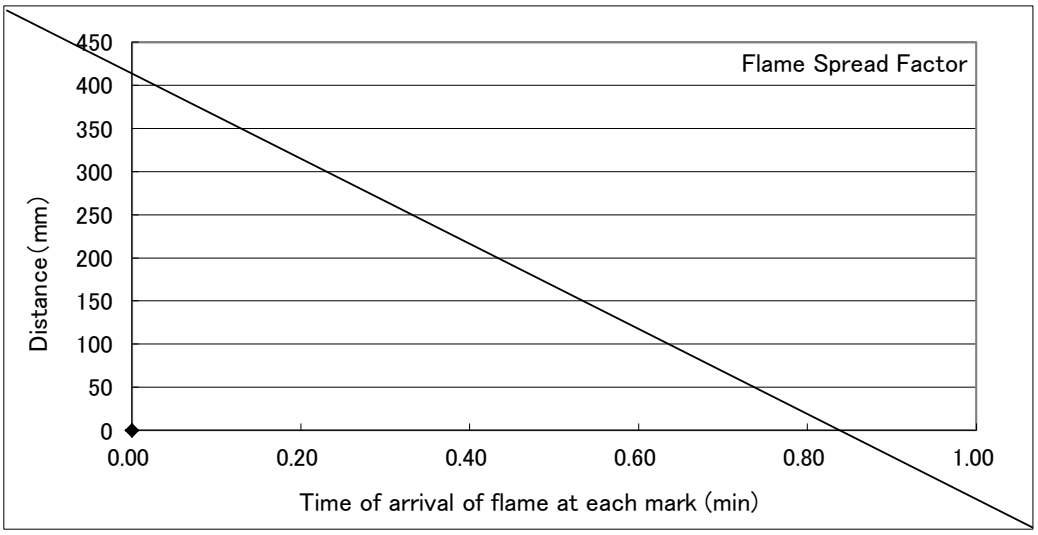
1. Flame spread factor, Fs

	Time of arrival of flame (min)	Distance (mm)	Slope between two marks		Slope inclination Inc／Dec		Skip points K	Flame Spread Factor Fs
t_0	0.00	0	–		–			
t_3	–	76	$t_3 - t_0$	–	–	–		
t_6	–	152	$t_6 - t_3$	–	–	–		
t_9	–	229	$t_9 - t_6$	–	–	–		
t_{12}	–	305	$t_{12} - t_9$	–	–	–		
t_{15}	–	381	$t_{15} - t_{12}$	–	–	–		1.00

Equation to calculate the flame spread factor :

$$Fs = 1 + \frac{1/(t_3-t_0)+1/(t_6-t_3)+1/(t_9-t_6)+1/(t_{12}-t_9)+1/(t_{15}-t_{12})}{}$$

2019-02-04 tk



2019-02-04 tk

2. Heat evolution factor, Q

Maximum thermocouple temperarure difference between the specimen and the cement board, T (℃)	Mean thermocouple temperature rise, β (℃)	Heat Evolution Factor, Q
7.4	33.6	1.3

Equation to calculate Heat evolution factor: $Q=CT/\beta$ (C: arbitrary constant of 5.7)

3. Flame spread index, Is 1.3

Equation to calculate Flame spread index: Is=Fs・Q

Note 1: 13mm thick millboard was used as a backing.
Note 2: No Flaming dripping observed.
Note 3: No flashing observed.

190080-RP

Table 4 Radiant Panel test result

Sample Name:	CASE-TOP,SNV-L6014RM;ADC12		
Sample thickness:	2mm	Material:	Aluminum+Coating
Sample No.:	4	Color:	Ivory
Sample Position:	Not applicable	Date of Test:	2019-01-29

Test results:

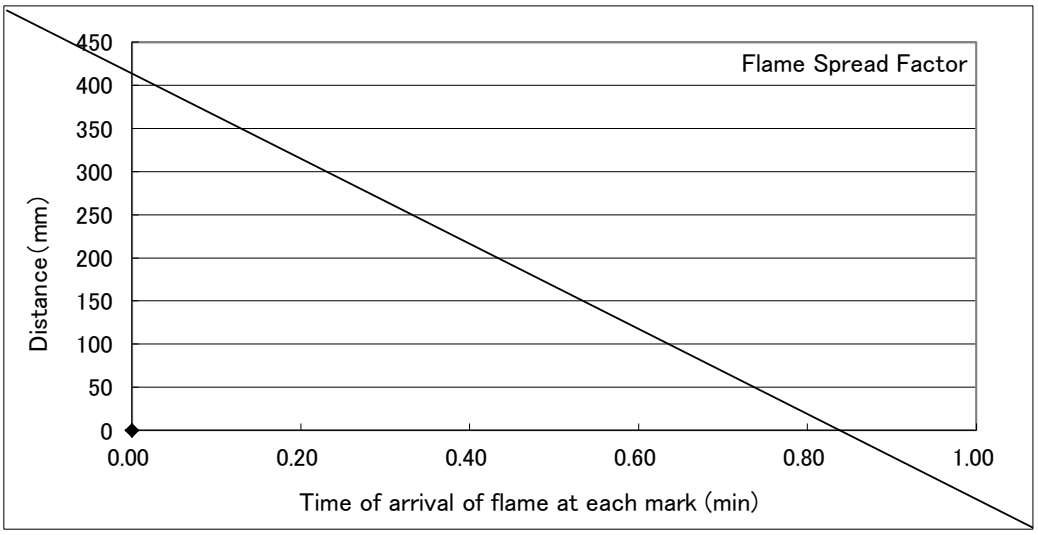
1. Flame spread factor, Fs

	Time of arrival of flame (min)	Distance (mm)	Slope between two marks		Slope inclination Inc／Dec		Skip points K	Flame Spread Factor Fs
t_0	0.00	0	–		–			
t_3	–	76	$t_3 - t_0$	–	–	–		
t_6	–	152	$t_6 - t_3$	–	–	–		
t_9	–	229	$t_9 - t_6$	–	–	–		
t_{12}	–	305	$t_{12} - t_9$	–	–	–		
t_{15}	–	381	$t_{15} - t_{12}$	–	–	–		1.00

Equation to calculate the flame spread factor :

$$Fs = 1 + \frac{1/(t_3 - t_0)+1/(t_6 - t_3)+1/(t_9 - t_6)+1/(t_{12} - t_9)+1/(t_{15} - t_{12})}{}$$

2019-02-04 tk



2019-02-04 tk

2. Heat evolution factor, Q

Maximum thermocouple temperarure difference between the specimen and the cement board, T (℃)	Mean thermocouple temperature rise, β (℃)	Heat Evolution Factor, Q
7.4	33.6	1.3

Equation to calculate Heat evolution factor: $Q=CT/\beta$ (C: arbitrary constant of 5.7)

3. Flame spread index, Is 1.3

Equation to calculate Flame spread index: Is=Fs・Q

Note 1: 13mm thick millboard was used as a backing.
Note 2: No Flaming dripping observed.
Note 3: No flashing observed.

190080-RP

ASTM E162 Radiant Panel (Flame Spread) Test Method

1. Applicable Standard : ASTM E162-16 "Standard Test Method for Surface Flammability of Materials Using a Radiant Heat Energy Source"

2. Objective : To evaluate the propagation characteristics of the flame over the material surface using radiant energy and calculate the flame spread index (certain standards referencing this standard may require the radiant panel index to be at a specific value. For example, paragraph 5.4.2 of the photovoltaic module standard IEC 61730-1 requires that radiant panel index be 100 or less).

3. Sample Size : 152 x 457 mm

4. Number of Samples : Minimum of 4 per 1 specimen

5. Sample Conditioning : Preconditioned at 60℃ for 24 hours and subsequently maintained at ambient temperature 23+/-3℃, relative humidity 50%+/-5% for a minimum of 24 hours.

6. Test Procedure :

Mount the sample backed with millboard (13 mm thick) on the sample holder and begin exposure to radiation with it inclined 30 degrees from the vertically installed radiant panel. During this, the distance between the sample and the radiant panel are 121 mm at the top part and 367 mm at the bottom part.

By arranging the sample in this manner, the high radiant energy at the top part of the sample declines as it moves down towards the bottom of the sample.
The radiant panel is heated to 670℃ beforehand, and the sample is ignited with a pilot burner from the top part of the sample.
The flame ignited at the top of the sample will spread downward, but since the radiant heat gradually declines, the rate of flame spread declines. At this time, the time by which the flame spreads the sample surface is measured for every 3 inches (76 mm), and the increase of temperature inside the exhaust duct above the apparatus is measured. This procedure is repeated for a minimum of 4 times.

In addition, a standard cement board is ignited using the same procedure to measure the increase of temperature inside the exhaust duct by itself as a standard burning temperature. The radiant panel index is calculated from the resulting measurement.

7. Method of Calculation :

1) The equation for calculating the radiant panel index (Is) is as follows:

Is = Fs Q

* Fs: flame spread factor

* Q: heat evolution factor

2) The standard equation for flame spread factor (Fs) is as follows:

$$Fs = 1 + \frac{1}{t_3 - t_0} + \frac{1}{t_6 - t_3} + \frac{1}{t_9 - t_6} + \frac{1}{t_{12} - t_9} + \frac{1}{t_{15} - t_{12}}$$

* Tx: the time (in minutes) at which the measurement point (x inches) located 3 inches apart was reached.

The flame spread factor (Fs) is the number obtained by adding 1 to the sum of 1 over the difference of the time at which the measurement point was reached and the time at which the previous measurement point was reached.

Additionally, a line graph is constructed with the distance every 3 inches as the vertical axis against the time at which the flame reached each 3-inch-mark as the horizontal axis. In this graph, a straight line is drawn from the previous point to the succeeding point at segments where the slope increases; i.e. the increase is eliminated by skipping the point at which the slope increases. This process is repeated as until slope increases are eliminated. The points that remain below the curve are the "skip points".

The data for the measurement point which became a "skip point" will be omitted from the equation for flame spread factor, and only values that are not skipped will be used for this calculation.

When substituting for the above equation, for fractions that have a difference where skip points exist as the denominator, term K in the table below shall be used as the denominator, which varies with the number of "skip points":

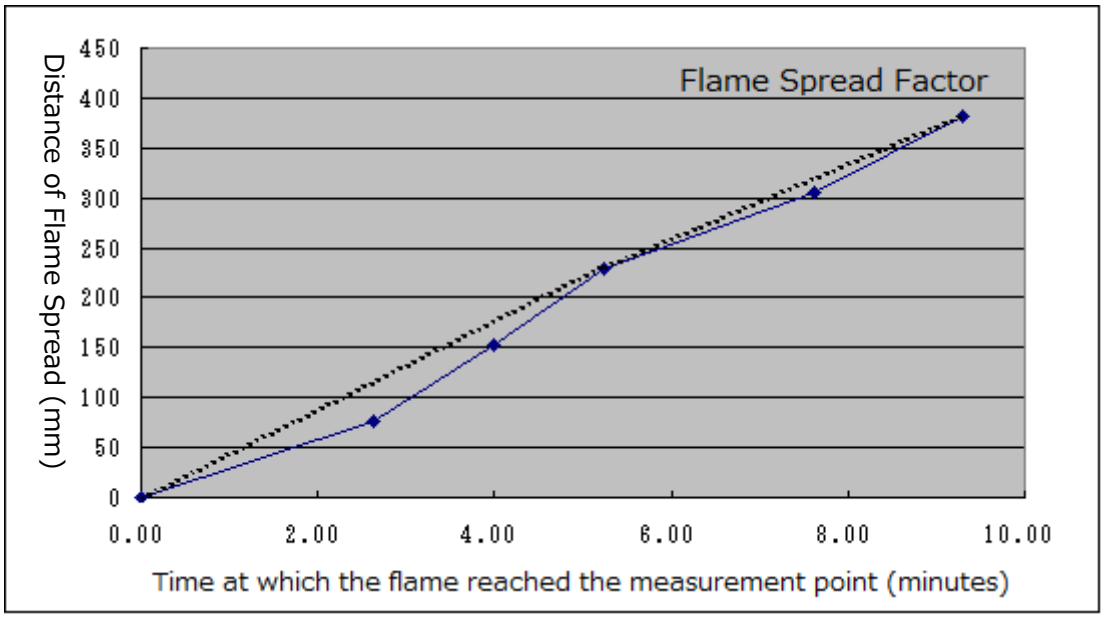
Number of skip points	K
One Single	4
Two Consecutive	9
Three Consecutive	16
Four Consecutive	25

An example of the calculation of flame spread factor with “skip points” is indicated below:

Calculation Example

Flame Spread Factor, Fs

	Time (minutes)	Distance (mm)	Slope Coefficient of Each Graph Segment		Increase/Decrease of Slope		Skip Point K	Flame Spread Factor, Fs
t_0	0.00	0	–		–			
t_3	2.63	76	$t_0 - t_3$	28.9	–	Increase		
t_6	4.00	152	$t_3 - t_6$	55.5	26.6	Increase	9	
t_9	5.23	229	$t_6 - t_9$	62.6	7.1	Increase		
t_{12}	7.63	305	$t_9 - t_{12}$	31.7	−30.9	Decrease	4	
t_{15}	9.30	381	$t_{12} - t_{15}$	45.5	13.8	Increase		3.70



From the above results,

$\frac{1}{t_3 - t_0} + \frac{1}{t_6 - t_3} + \frac{1}{t_9 - t_6}$ is replaced by $\frac{9}{t_9 - t_0}$ and

$\frac{1}{t_{12} - t_9} + \frac{1}{t_{15} - t_{12}}$ is replaced by $\frac{4}{t_{15} - t_9}$, and

the equation for flame spread factor becomes:

$$Fs = 1 + \frac{9}{t_9 - t_0} + \frac{4}{t_{15} - t_9}$$

3) The equation for heat evolution factor is as follows:

$Q = CT / \beta$

* C: constant 5.7

* T: the maximum thermocouple temperature difference (℃) in the chimney between the sample and standard cement board combustion.

* β Mean thermocouple temperature increase in the chimney (℃/Kw), calculated during the calibration of the test apparatus.

8. Evaluation Criteria : Pass/fail is not determined by ASTM E162, and the radiant panel index is the test result. However, certain standards and company specific standards that reference the ASTM E162 require a certain value, and if this value is not satisfied, the material is determined to be nonconforming.

For Example, IEC 61730-1, Standard for Photovoltaic Module Materials, requires a radiant panel index 100 or less, and if the radiant panel index exceeds this value, it is considered not compliant.

Revision History

Issue No: 2	Revised Date: March 18, 2019
Revised by: Takemaru Kunugi	
Reason for Revision: Based on the client's request, Product Name of item 3 in page 2 was replaced from "CASE-TOP, SNV-L6014RM;ADC12" to "XNV-6022RM", and Part List Name "CASE-TOP, SNV-L6014RM;ADC12" was added to item 3 in page 2.	

SGS GOVMARK

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Farmingdale, New York 11735-5626 USA
Tel. +1 (631) 293-8944 Fax +1 (631) 293-8956
email: govmark.accounting@sgs.com

Received:01/17/2019	Completed:01/22/2019	Letter: R	AM	P.O.#: IB19011	Test Report #:	3-30424-0-
Client's Identification	Composition: Coated aluminum plate. Undercoat: "AKZO Nobel", 821KA-WJS-1193, white color, Top coat: "AKZO Nobel", 822KA-WJS-8635, Ivory color (see continuation)					

Tested For: **Masao Fujiwara**
Hanwha Techwin Co., LTD
6 Pangyo-ro 319beon-gil, Bundang-gu
Seongnam-siGyoenggi-do13488Korea

Key Test: ASTM E662 12S 925

Tel: 011 8270 71475426 **Ext:**
Fax:

CLIENT'S IDENTIFICATION (continuation):

Thickness: Aluminum plate 2mm, coating (two layers) 20~25um.
Additional Information: Product Name: Case Top, SNV-L6014RM-ADC12.
[Coated side exposed to test heat source]

Category: Smoke Density Specifier: ASTM LE 2017a; V 11/17 PC: 24H+ME
CODE: 725(6S); 925(12S) SM/mg

TEST PERFORMED: ASTM E662 - Standard Test Method For Specific Optical Density of Smoke Generated by Solid Materials (NFPA Designation No. 258)

APPROXIMATE THICKNESS OF MATERIAL (as measured by SGS Govmark): 0.081"

BRIEF DESCRIPTION OF TEST: Two separate tests are conducted on three specimens. In one test, the face of each specimen is exposed to a radiant heat source of 2.5 W/cm² (non-flaming mode). In a second test, completely new specimens are subjected to both the radiant heat source and six small igniting flames (flaming mode). As smoke accumulates in the test chamber, the percent light obscuration is converted to a smoke density value. Typically, the highest value within a maximum test period of 20 minutes is recorded, along with interim value at 90 seconds and 4 minutes.

At the conclusion of the test, a minus adjustment is made (clear beam reading) for any particles deposited on the optical windows.

REMARKS: None.

-- See Page 2 for "Results" --

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Received:01/17/2019	Completed:01/22/2019	Letter: R	AM	P.O.#: IB19011	Test Report #: 3-30424-0-

Client's Identification Composition: Coated aluminum plate. Undercoat: "AKZO Nobel", 821KA-WJS-1193, white color, Top coat: "AKZO Nobel", 822KA-WJS-8635, Ivory color (see continuation)

Tested For: **Masao Fujiwara**
Hanwha Techwin Co., LTD
6 Pangyo-ro 319beon-gil, Bundang-gu
Seongnam-siGyoenggi-do13488Korea

Key Test: ASTM E662 12S 925

Tel: 011 8270 71475426 **Ext:**
Fax:

RESULTS:

	Specimen #	Flaming Mode	Non Flaming Mode
90 Seconds: Specific Optical Density	1	0	0
	2	0	0
	3	0	0
	4	0	0
	5	0	0
	6	0	0
	Avg:	0	0
4 Minutes: Specific Optical Density	1	15	0
	2	2	0
	3	2	0
	4	14	0
	5	3	1
	6	3	0
	Avg:	7	0
Within 20 Minutes: Maximum Specific Optical Density	1	21 (20)	19 (19)
	2	22 (22)	25 (24)
	3	21 (21)	15 (14)
	4	19 (19)	16 (16)
	5	18 (17)	23 (22)
	6	21 (21)	14 (14)
	Avg:	20 (20)	19 (18)

CORRECTION FACTOR: At the conclusion of each test, combustion particles are removed from the glass protecting the photodetector. The corrected value in parentheses is used to recognize what may be a change in light obscuration.

ABBREVIATION WHICH MAY BE USED: NR = Not required.

ACCEPTANCE CRITERIA: None cited.

CONCLUSION: Not applicable.

CERTIFICATION: I certify that the above results were obtained after testing specimens in accordance with the procedures and equipment specified above.

JAN 29 2018

Bobby Brown

CHEMI-JP/HANWHAT/CHEMI-JP

AUTHORIZED SIGNATURE
SGS GOVMARK
/gb /pm

The results contained in this report relate only to item(s) tested. The test report shall not be reproduced, except in full, without written approval from Govmark.

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TOXICITY CERTIFICATE
BOEING BSS 7239 Flaming

Herb Curry, Inc. has been accredited to ISO/IEC 17025:2005 for testing. PJLA Accreditation #80445

REQUESTOR: Hanwha Techwin Co., LTD
6, Pangyo-ro 319beon-gil, Bundang-gu
Seongnam-si, Gyoenggi-do,
13488 Korea

PHONE: 82-70-7147-5426 DATE: 1/18/2019

Attn: Masao Fujiwara

Email: m.fujiwara@hanwha.com

Sample ID: Case-Top, SNV-L6014RM;ADC12
Composition: Coated Aluminum Plate,
Undercoat: "AKZO Nobel" 821KA-WJS-1193, white color
Top Coat: "AKZO Nobel" 822KA-WJS-8635, ivory color
Thickness: Aluminum plate 2mm, coating (two Layers) 20~25um

Thickness: 2.0 mm
PO#: IB19011
Physical Condition of Samples: Good

REFERENCE: Chamber S/N 61900, BSS 7239
Dräeger Tubes (DT), Potentiometry (PO), Gas Flue Analysis (Testo 350) (GF)

RESULTS:

GASSES	LIMITS @ 4 MIN	FLAMING		P/F	FLAMING		P/F	FLAMING		P/F
		Result	Method		Result	Method		Result	Method	
HCN	150 PPM	<1	☒ DT	P	<1	☒ DT	P		☐ DT	
CO	3500 PPM	10	☐ DT ☒ GF	P	10	☐ DT ☒ GF	P		☐ DT ☐ GF	
NO/NO²	100 PPM	1	☐ DT ☒ GF	P	1	☐ DT ☒ GF	P		☐ DT ☐ GF	
SO²	100 PPM	2	☐ DT ☒ GF	P	1	☐ DT ☒ GF	P		☐ DT ☐ GF	
HF	100 PPM	*<1	☒ DT	P	<1	☐ PO ☒ DT	P		☐ PO ☐ DT	
HCL	150 PPM	10	☒ DT	P	8	☒ DT	P		☐ DT	

Note: IND. = Indeterminate. Test values exceed maximum limits of Dräger tube.
Positive = Indicative test; HF is detected

Tested by: Scott VanWormer **Date:** 1-18-19

Authorized by: Scott VanWormer **Position:** Vice-President

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Results contained in this report are reflective only of the items tested. The unique ID# of the test report is the test report date and unique sample ID#.

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TOXICITY CERTIFICATE
BOEING BSS 7239 Non-Flaming

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PHONE: 82-70-7147-5426 DATE: 1/18/2019

Attn: Masao Fujiwara

Email: m.fujiwara@hanwha.com

Sample ID: Case-Top, SNV-L6014RM;ADC12
Composition: Coated Aluminum Plate,
Undercoat: "AKZO Nobel" 821KA-WJS-1193, white color
Top Coat: "AKZO Nobel" 822KA-WJS-8635, ivory color
Thickness: Aluminum plate 2mm, coating (two Layers) 20~25um

Thickness: 2.0 mm
PO#: IB19011

Physical Condition of Samples: Good

REFERENCE: Chamber S/N 61900, BSS 7239
Dräeger Tubes (DT), Potentiometry (PO), Gas Flue Analysis (Testo 350) (GF)

RESULTS:

GASSES	LIMITS @ 4 MIN	Non-FLAMING		P/F	Non-FLAMING		P/F	Non-FLAMING		P/F
		Result	Method		Result	Method		Result	Method	
HCN	150 PPM	<1	☒ DT	P	<1	☒ DT	P		☐ DT	
CO	3500 PPM	2	☐ DT ☒ GF	P	3	☐ DT ☒ GF	P		☐ DT ☐ GF	
NO/NO²	100 PPM	0	☐ DT ☒ GF	P	0	☐ DT ☒ GF	P		☐ DT ☐ GF	
SO²	100 PPM	1	☐ DT ☒ GF	P	1	☐ DT ☒ GF	P		☐ DT ☐ GF	
HF	200 PPM	* <1	☒ DT	P	<1	☐ PO ☒ DT	P		☐ PO ☐ DT	
HCL	500 PPM	3	☒ DT	P	5	☒ DT	P		☐ DT	

Note: IND. = Indeterminate. Test values exceed maximum limits of Dräger tube.
****Positive = Indicative test; HF is detected***

Tested by: Scott VanWormer **Date:** 1-18-19

Authorized by: Scott VanWormer **Position:** Vice-President

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