Fire hazard in televisions

Comparative analysis of television sets sold in Brazil and the United States point to a real risk of fire in Brazilian equipment

Considering the poor results presented by Brazilian televisions assessed in a study by the Southwest Research Institute (SwRI), as reported in the article Combustion Characteristics of Flat Panel Televisions With and Without Fire Retardants in the Casing, the IPT wants to improve, with the support of the Brazilian Flame Retardant Industry association (Abichama), the assessment of Brazilian televisions to collect comparative data that can be used to set performance evaluation criteria related to the control of the risk of fire of televisions sold in Brazil.

The technical requirements set out by the ABNT NBR IEC 60065:2009 standards - Audio, video and similar electronic devices - Safety requirements - which are intended to prevent injuries and damage to users due to the following risks: electric shock, excessive temperatures, radiation, implosion, mechanical hazards and fire, and the ignitability test methods IEC 60695 - Fire hazard testing, were taken as a benchmark and complemented with a dynamic calorimetry assessment, in which the televisions considered in the study were subjected to tests equivalent to real fire simulation.

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FOTOS: ARQUIVO IPT

It is noteworthy that part of the IEC 60695 test methods employed have corresponding versions ABNT NBR IEC 60695.

TV fire, according to IEC 60065:2009, can result from overload, component failure, insulation breakdown, poor connection, and arcing. To prevent any fire from inside the appliance from spreading beyond the immediate vicinity of the fire source or causing damage to the surroundings of the appliance, the standard recommends the following preventive measures: use suitable components and subassemblies; avoid excessive temperatures that could ignite under normal or fault conditions; adopt measures to eliminate potential sources of ignition, such as inadequate contacts, bad connections, and circuit interruptions; limit the amount of combustible material used; control the position of flammable materials in relation to potential sources of ignition; use encapsulation or barriers to limit the spread of fire inside the appliance and use suitable fire retardant materials for the casing.

Also, according to ABNT NBR IEC 60065, the appliances must be designed in such a way that the ignition and propagation of fire are prevented, and also must not cause a fire risk to the vicinity of the appliance as follows: through sound engineering practices, in order to avoid potential sources of ignition, such as, for example, the printed circuit board that gets the power from the electrical grid and by the use of enclosures capable of limiting the risk of involvement of the entire apparatus in the fire.

COMPARATIVE ANALYSIS

Brazilian and American televisions were purchased, both 32 inches, from the same manufacturer. These televisions were dismantled and analyzed to verify their similarities. Despite being of different models, both Brazilian and American televisions had equivalent designs, including internal and external constructive characteristics and internal circuit boards of the same model. This condition proved to be adequate for the comparative analysis performed. See Photos 1 to 4.

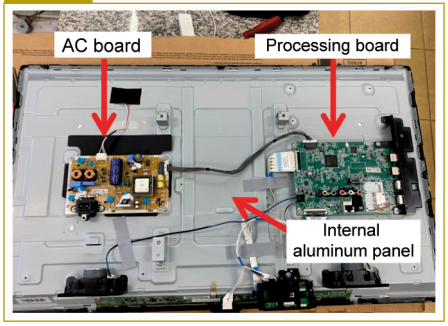
Brazilian and American televisions, powered by a nominal operating voltage of 127 Vac and 120 Vac, respectively, for 24 hours, presented values very close to the calculated average active power, as described in Table 1. It is possible to ensure that Brazilian and American TVs have the same operating standard. It was found that the working temperatures of the internal components also presented similar values, as described in Table 1.

Picture 1 Back view of the Brazilian TV

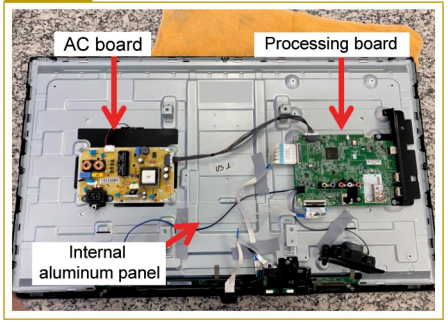
Picture 2 Back view of the American TV

As part of the comparative analyses, the amounts of polymeric materials in both televisions were identified, as described in Table 2.

Picture 3 Internal components of the Brazilian TV



Picture 4 Internal components of the American TV



The preponderant amounts of polymeric materials in both televisions, Brazilian and American, are associated with the casing. In addition, the electrical connection of the televisions is inserted in the casing, posing a risk situation in which a failure in the components of this connection will directly impact it and could ignite it if it is vulnerable to ignition from a small heat source. Also, it is important to consider external ignition sources, such as votive candles that may inadvertently be placed too close to these casings. Considering these situations, the relevance of the ignitability features of the TV casings is understood to establish the risk of fire and, consequently, the significance of the use of polymeric material in its composition that has good performance in terms of fire safety.

The television casings were also chemically analyzed to identify the polymeric material. Both casings were made up of the same type of polymer, ABS (Acrylonitrile Butadiene Styrene); however, in the American television sample, a flame retardant additive was identified as a polybrominated compound, which did not feature in the Brazilian television sample.

Table 1 Average values of TV voltage, current, active consumed power calculate and temperature

TV	Voltage (Vac)	Current (Amp)	Active Power (W)	AC Board 1 (°C)		AC Board 2 (°C)		Processing Board 3 (°C)		Room Temperature (°C)	
				Med	Max	Med	Max	Med	Max	Med	Max
Brazilian	127	0.413	52.5	27	28	33	34	37	39	21	22
American	120	0.446	53.5	26	27	30	31	33	35	19	20

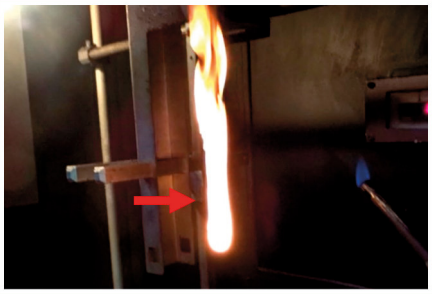
Table 2 TV components mass

Component	Brazilian TV		American TV	
	(g)	%	(g)	%
Circuits, internal flat cables, speakers, LED strip lights, liquid crystal display	1,414.7	28.7	1,387.8	29.0
Internal aluminum panel	1,412.4	28.6	1,379.1	28.8
Casing	1,191.8	24.2	1,145.5	23.9
Miscellaneous polymeric materials: edges, internal films, etc.	913.8	18.5	875.2	18.3
TOTAL	4,934.6	**100**	4,787.6	**100**

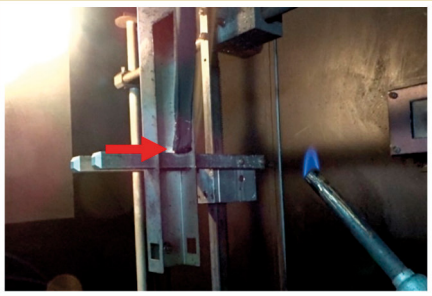
Table 3 Material classification criteria according to the IEC 60695-11-10 method

Classification criteria	V-0	V-1	V-2
Individual flare time (t1) or (t2) from any specimen	< 10s	< 30s	< 30s
Total flare time (t1+ t2) for 5 specimens	< 50s	< 250s	< 250s
Flare and glow time (t1+ t2) from each specimen	< 30s	< 60s	< 60s
Flare and scorching reached the full extent of the specim	No	No	No
Cotton ignited by glowing material or dripping	No	No	Yes

Picture 5 Brazilian TV casing: continuous material burning



Picture 6 American TV casing: material burning put out



IGNITABILITY

The first method used to distinguish the ignitability of television casings was the IEC 60695-11-10: 2013 - "Fire Hazard Testing - Part 11-10: Test flames - 50 W horizontal and vertical flame test methods - Test method B - Vertical burning test". This method is considered essential to qualify polymeric materials used in electronics, establishing a minimum safety condition, namely ire risk control. The V-0 classification and, in some cases, V-1, is considered in several parts of the ABNT NBR IEC 60065:2009 - Audio, video, and similar electronic devices - Security requirements. However, it does not embrace explicit and easily identifiable requirements for the TV casing as a whole. This lack of transparency gives rise to the first and important differentiation between Brazilian and American televisions, as shown in Table 3.

According to the results, it was impossible to put the Brazilian television casing into any category, proving its poor performance. The American television casing fell into the best category, i.e., V-0. See Photos 5 and 6.

Picture 7 Brazilian TV casing: burning after the glow wire was removed and flare particles drop

Picture 8 American TV casing: no burning after the glow wire was removed

The second method used to distinguish the ignitability of television casings was the IEC 60695-2-11: 2014 standard - *Fire hazard testing - Part 2: 11: Glow/Hot-wire based test methods - Glow-wire flammability test methods for end-products* (GWEPT). After establishing the critical temperature at 750°C, the casings of the Brazilian television and the American television were subjected to a heated wire that simulates, for a short period, the effects caused by heat sources resulting from incandescent elements or resistors with overvoltage.

The results showed that, for the application temperature of 750°C (GWEPT), the casing of the American television met the criteria specified in the standard, while the casing of the Brazilian television did not. See Photos 7 and 8 and Table 4.

The third method used was the IEC 60695-2-12: 2014 standard - *Fire hazard testing - Part 2: 12: Glow/Hot-wire based test methods - Glow-wire flammability test methods for materials.* This method makes it possible to compare the burning behavior of different polymeric materials used in products and electronics, such as the casings of American and Brazilian televisions, by establishing the flammability index (glow-wire). flammability index - GWFI).

The results showed that the ignition temperature of the sample of polymeric material from the Brazilian television casing was 700°C, with some gray and black smoke, dripping and falling particles on fire with the ignition of the tissue. As for the sample of polymeric material from the American television, the ignition temperature was also

Table 4 Summary of casing test results according to the IEC 60695—2-1: 2014 standard

TV	Glow wire application time (s)	Glow wire temperature (°C)	Material Ignition Time (s)	Paper Tissue Ignition (s)	Time to put out the flame on the material after the removal of the glow wire (s)
Brazilian	30	750	1	Yes	>300
American	30	750	1	No	1

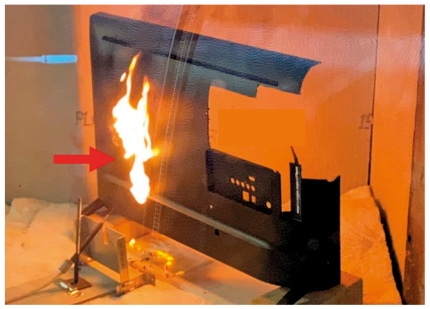
Table 5 Summary of TV casing test results according to the IEC 60695—2-1: 2014 standard

TV	Glow wire temperature (°C)	Glow wire application time (s)	Ignition during and after the glow wire application (yes/no)	Flame Duration Time (s)	Flame time Paper Tissue Ignition (yes/no)
Brazilian	700	30	Yes	>300	Yes
American	960	30	Yes	3	No

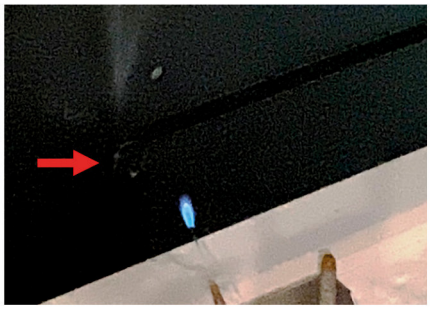
Table 6 Summary of casing test results according to the IEC 60695—2-1: 2014 standard

TV	Flame application time (s)	Flare or scorching time after burner is removed (s)	Flame dripping or glowing particles falling
Brazilian	10	>200	Yes
American	10	1	No

Picture 9 Brazilian TV casing: burning and dripping on fire



Picture 10 The American TV casing was not burned



Picture 11 SBI equipment – Single Burning Item where the real fire simulations were performed for the Brazilian and American TVs

700°C, with some gray smoke. However, when the glowing wire was removed from the specimen, the flame was extinguished, and there was no dripping and falling particles on fire during and after applying the glow wire in the test. See Table 5.

According to the criteria established in the IEC 60695-2-12 standard, the polymeric material of the Brazilian television casing was classified as GWFI: 700/2.4, and the polymeric material of the American television casing was classified as GWFI: > 960/2.0, i.e., at a much higher grade. The indicated values of 2.4 and 2.0 correspond to the thickness in mm of the respective tested casings.

The last method used for the assessment of the television casings was the IEC 60695-11-5: 2016

- Fire hazard testing - Part 11- 5: Test flame - Needle-flame test method - Apparatus, confirmatory, test arrangement, and guidance. This method establishes the following criteria for the tested material to perform satisfactorily: the flame and/or burning time must not exceed 30 seconds after the burner is removed; there must be no ignition of the tissue paper or carbonization of the wooden board.

The results showed that the Brazilian television casing did not meet the criteria specified by the IEC 60695-11-5 standard and the American television casing easily met the requirements. See Table 6, Photos 9 and 10.

FIRE SIMULATION

Fire simulation tests on televisions were performed using the equipment to establish the performance regarding the reaction to fire of construction materials when exposed to a single standard flame (SBI - Single Burning Item). The use of this equipment allowed the measurement of the heat release rate (HRR) and the total heat release of the material (THR) from the burning of the televisions. See Photo 11.

Based on the ignitability tests carried out on the casings of both televisions, flames with different energy values were used for the Brazilian and American televisions. For the American television, the flame applied was much more intense, as its casing showed good performance in the IEC 60695-11-10 standards testing, where two applications of a 50 W flame are carried out for 10 seconds each, and the IEC 60695-11-20:2015, with five applications of a 500 W flame lasting five seconds each, with a five-second pause between applications. Thus, the following flame application conditions were considered: Brazilian television - 50 W flame with two sequential applications of 10 seconds, set by the IEC 60695-11-10 standard; American television - 500 W flame with continuous application for three minutes. In the real fire simulation of the Brazilian television, after removing the flame from the second application, it was found that the polymeric material ignited and spread to the entire television set.

See Photos 12 to 17. In the real fire simulation of the American television, after removing the flame, it was found that the polymeric material of the American television casing kept the flames on for only 15 seconds and that the fire did not set in the device.

See Photos 18 to 21. The values of the heat release rate (HRR), total heat release from the material (THR), and other data from the burning of the televisions are presented in Table 7. All these conditions from the Brazilian

Picture 12 50W flame application

Picture 13 2 minutes into the test

Picture 14 4 minutes into the test

Picture 15 6 minutes into the test

televisions indicate that, in addition to being easily ignited, it can become a strong fire source capable of causing fires in buildings.

CONCLUSION

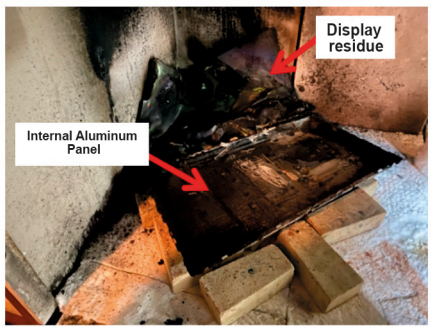
The study carried out by SwRI also concluded that the main risk of the television set starting a fire is associated with its casing, which, in addition to incorporating a significant amount of polymeric material, it is close to the device's power supply components, that is, the AC circuit.

The casing of the Brazilian television proved to be, in terms of ignitability characteristics, much inferior to the American television casing, and in the burning test, it proved to be highly vulnerable to igniting from a small flame, allowing the television, eventually, to become a major source of fire. The striking difference between the casings of both televisions is the fact that in the case of the Brazilian television, no flame retardant product was added.

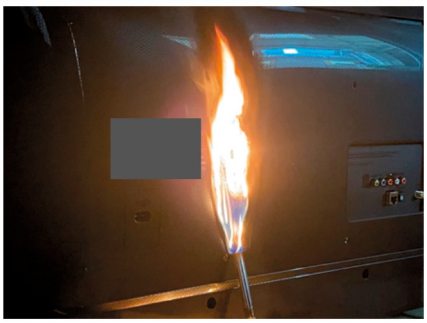
The need for adaptation of Brazilian televisions is evident, taking into account the risk of fire. The current study highlights the relevance of the casing in this situation. The ABNT NBR IEC 60065:2009 standard should be improved regarding this issue, taking as a reference, for example, the test results from American televisions. With this in mind, it is critical to adopt criteria for Brazilian televisions casings, compliant with the GWEPT criterion, of the IEC 60695-2-11 standard, at 750°C and approval in the test carried out according to IEC 60695-2-20 with 500 W flame.

Picture 16 **20 minutes into the test**

Picture 17 **End of the real fire simulation test for the Brazilian TV**



Picture 18 **50W flame application on the American TV casing**



Picture 19 **Flare dripping from the American TV polymeric material**

*After 3 minutes of application of the 500w flame

Picture 20 **External damage to the American TV**

Picture 21 **Internal damage to the American TV**

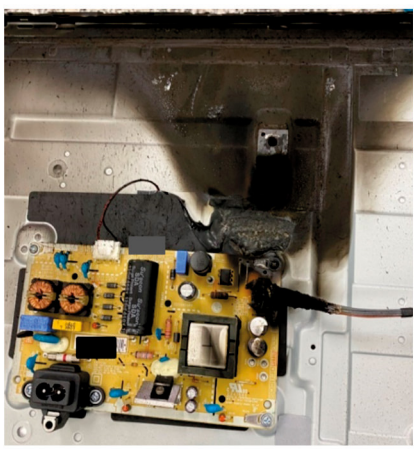


Table 7 TVs real fire simulation result

TV	Ignition source / Time	HRR Maximum (kW)	Maximum HRR (s)	THR (MJ)	Initial Mass (g)	End Mass (g)	Mass Loss (g)
Brazilian	50 W/(10+10) s	207.0	690	41.0	4,932.6	2,926.3	2,006.3
American	500 W/180 s	0.50	278	0.1	4,787.6	4,776.0	11.6

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