SAE INTERNATIONAL

AEROSPACE RECOMMENDED PRACTICE

ARP6330™ REV. A

Issued 2018-09
Revised 2024-06

Superseding ARP6330

(R) Methods to Evaluate Impact Characteristics of Seat Back Mounted IFE Monitors

RATIONALE

Added criteria for newly developed component impact test for seat back monitors, revised engineering rationale section, and added a description of how monitor component test data should be used by those integrating the monitor into seat designs.

TABLE OF CONTENTS

TO PLACE A DOCUMENT ORDER: Tel: 877-606-7323 (inside USA and Canada)
Tel: +1 724-776-4970 (outside USA)
Fax: 724-776-0790
Email: CustomerService@sae.org
SAE WEB ADDRESS: http://www.sae.org

For more information on this standard, visit
https://www.sae.org/standards/content/ARP6330A

1. SCOPE

This SAE Aerospace Recommended Practice (ARP) defines means to assess the effect of changes to seat back mounted IFE monitors on blunt trauma to the head and post-impact sharp edges. The assessment methods described may be used for evaluation of changes to seat back monitor delethalization (blunt trauma and post-test sharp edges) and head injury criterion (HIC) attributes (refer to ARP6448, Appendix A, Item 4). Application is focused on type A-T (transport airplane) certified seat installations.

1.1 Background

To meet the HIC of AS8049, seat manufacturers may be required to perform row-to-row seat dynamic testing to assess the seat design's ability to attenuate head impact severity, as measured by the HIC. As part of the test, seat back mounted IFE components such as monitors and handsets are included in the tested configuration of the seat. While the primary purpose of the HIC test is to measure the HIC value, the seat is also evaluated in its post-test state for unacceptable sharp edges, loose pieces, and potential occupant egress impediments. Numerous difficulties for seat manufacturers, IFE manufacturers, and the seat installer occur when demonstrating and maintaining compliance.

a. Obsolescence of parts within the IFE component is driven by the rapid pace of change in the consumer electronics industry. Therefore, evaluation of IFE component changes for effects on HIC and post-impact sharp edges is frequently performed by the IFE manufacturer, seat manufacturers, and the seat installers. As an IFE component can be integrated within various seat designs manufactured by multiple seat manufacturers, a single change to an IFE component design could affect a large number of different seat installations.

b. Seat manufacturers are knowledgeable in seat system behavior, while IFE manufacturers are knowledgeable about the construction of their IFE components. Test failures that include both the seat and the integrated IFE part (especially unacceptable post-impact sharp edges of the IFE component) are problematic due to shared involvement in the integrated seat design. Therefore, it can be difficult to identify the design change needed to meet requirements.

Although FAA policy allows for more streamlined methods to be used, such as seat dynamic testing with surrogate targets, the criteria defined in current policy is very conservative, which has prevented its widespread use.

2. REFERENCES

2.1 Applicable Documents

The following publications form a part of this document to the extent specified herein. The latest issue of SAE publications shall apply. The applicable issue of other publications shall be the issue in effect on the date of the purchase order. In the event of conflict between the text of this document and references cited herein, the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

2.1.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or +1 724-776-4970 (outside USA), www.sae.org.

AIR6908 Impact Characteristics of Seat Back Mounted IFE Monitors - Basis for ARP6330

ARP5526 Aircraft Seat Design Guidance and Clarifications

ARP6448 Gaining Approval for Seats with Integrated Electronics in Accordance with AC 21-49 Section 7.b

AS8049 Performance Standard for Seats in Civil Rotorcraft, Transport Aircraft, and General Aviation Aircraft

SAE J211-1 Instrumentation for Impact Test, Part 1 - Electronic Instrumentation

2.1.2 FAA Publications

Available from Federal Aviation Administration, 800 Independence Avenue, SW, Washington, DC 20591, Tel: 866-835-5322, www.faa.gov.

14 CFR Part 25	Airworthiness Standards: Transport Category Airplanes
AC 21-49	Gaining Approval of Seats with Integrated Electronic Components (February 9, 2011)
AC 25.562-1B Change 1	Dynamic Evaluation of Seat Restraint Systems and Occupant Protection on Transport Airplanes (September 30, 2015)
AC 25-17A Change 1	Transport Airplane Cabin Interiors Crashworthiness Handbook (May 24, 2016)
ANM-03-115-28	Policy Statement on Use of Surrogate Parts When Evaluating Seatbacks and Seatback Mounted Accessories for Compliance with §§ 25.562(c)(5) and 25.785(b) and (d) (October 2, 2003)
ANM-03-115-31	Policy Statement on Conducting Component Level Tests to Demonstrate Compliance with §§ 25.785(b) and (d) (May 9, 2005)

2.1.3 ASTM Publications

Available from ASTM International, 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA 19428-2959, Tel: 610-832-9585, www.astm.org.

ASTM D6272-17	Standard Test Method for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials by Four-Point Bending

2.1.4 Code of Federal Regulations (CFR) Publications

Available from United States Government Printing Office, 732 North Capitol Street, NW, Washington, DC 20401, Tel: 202-512-1800, www.gpo.gov.

49 CFR Part 572	Anthropomorphic Test Devices

2.2 Definitions

BASELINE IFE MONITOR: The IFE monitor configuration in which the integrated seat was validated for acceptable head impact performance.

GLASS FAMILY: Glass materials where both the material chemistry and methods used to toughen the glass are similar.

HEAD INJURY CRITERION (HIC): A measure of head impact blunt trauma severity as defined in 14 CFR Part 25.562(c)(5).

INTEGRATED SEAT: An airplane seat approved under a seat TSOA/LODA that includes electronic components. The electronic components may include IFE, in-seat power systems, inflatable restraints, and electrically actuated seat features.

NON-HIC: Seat installation not required to meet the HIC.

REVISED IFE MONITOR: The IFE monitor configuration proposed to be substituted for the baseline IFE monitor in an integrated seat design.

SURROGATE TARGET: An acceptable substitute for a production part per FAA memorandum ANM-03-115-28.

TOUCH SCREEN: An input and output device normally layered on the top of an electronic visual display. For this document the term “touch screen” is used generically to be the outer surface of the visual display, even though the component may not have input/output functionality. This component may also go by the term cover glass, cover lens, or touch panel in monitor construction.

2.3 Acronyms

AC	Advisory Circular
AIR	Aerospace Information Report
ARP	Aerospace Recommended Practice
AS	Aerospace Standard
ASTM	American Society of Testing and Materials
ATD	Anthropomorphic Test Device
CFR	Code of Federal Regulations
FAA	Federal Aviation Administration
FEM	Finite Element Model
FMH	Free Motion Headform
HCTD	Head Component Test Device
HIC	Head Injury Criterion
IFE	In-Flight Entertainment
LODA	Letter of Design Approval
PCB	Printed Circuit Board
TSO	Technical Standard Order
USB	Universal Serial Bus

3. SEAT BACK MONITOR CONSTRUCTION

Seat back mounted IFE monitor designs typically consist of layers of subcomponents (touch screen, display panel, and circuit boards) packaged in a boxlike structure. A shroud envelops the outer surfaces potentially exposed to the passenger. See Figure 1 for an illustration of IFE monitor construction.

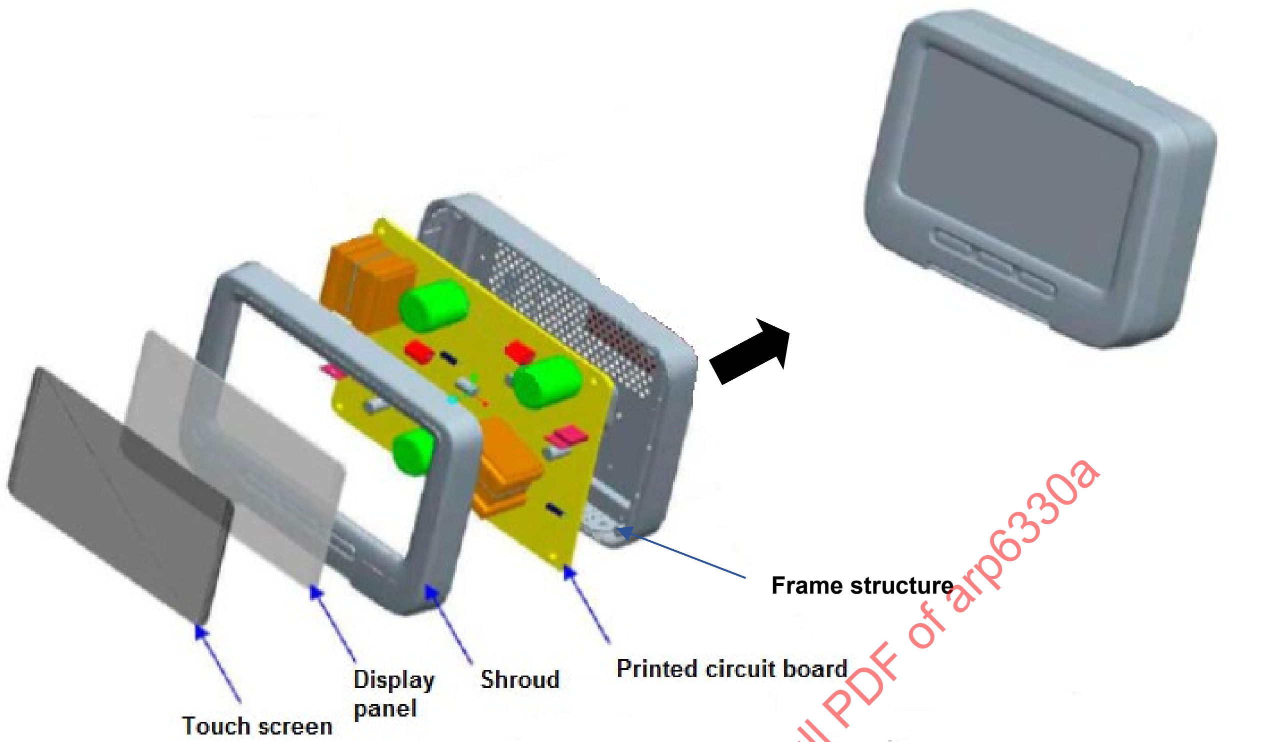

Figure 1 - Exploded view of IFE monitor (example)

The touch screen is a multi-layered panel typically consisting of polymer films, glass, adhesives, and sensors. A typical construction is shown in Figure 2. The polymer protective film functions to protect the glass from damage and to retain glass fragments if the glass fractures. The typical touch screen panel installation has an air gap with other subcomponents (typically the display panel) located farther into the IFE monitor.

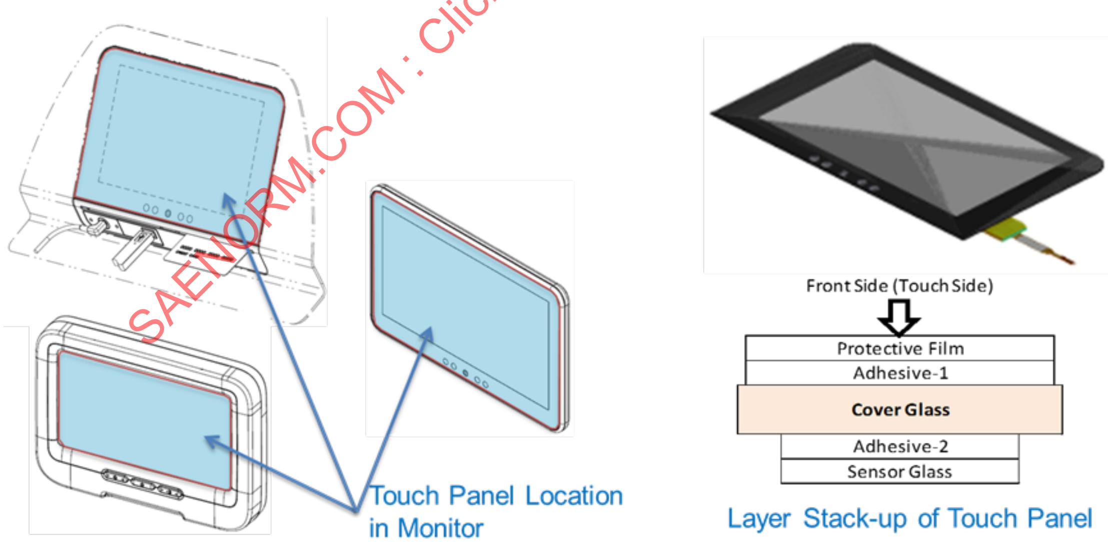

Figure 2 - Touch screen stack-up (typical)

A display panel (e.g., liquid crystal display) is typically mounted between the touch screen and the printed circuit board, with air gaps between the display panel and neighboring subcomponent layers. Printed circuit boards used in monitors are typical of those used in the consumer electronics industry and provide a mechanical support and electrical connection for a power supply, integrated circuits, and other electrical small parts such as resistors or capacitors.

For the rest of the document the term "touch screen" will be used to describe the outermost glass panel of the monitor construction, even though for some IFE monitor designs the panel does not have touch-sensitive functionality or goes by a different name (cover glass, cover lens, touch panel, etc.).

4. APPLICABLE ASSESSMENT METHODS FOR SUBCOMPONENT CHANGES

The assessment methods described in Section 5 are listed below in order of complexity, from most complex to least complex.

a. Row-to-row HIC test (blunt trauma and post-impact sharp edges) (see 5.1)

b. Head component test of integrated seat back (blunt trauma and post-impact sharp edges) (see 5.2)

c. Component impact test (post-impact sharp edges) (see 5.7)

d. Three-point bend test (blunt trauma) (see 5.3)

e. Four-point bend test (glass material and touch screen; blunt trauma) (see 5.4 and 5.5)

f. Engineering rationale (blunt trauma and post-impact sharp edges) (see 5.6)

The first two methods (a and b) involve testing the IFE monitor installed in the seat back. While these methods can evaluate changes to the seat back, IFE monitor installation, or one or more subcomponents within the IFE monitor, the evaluation is specific to the integrated seat design tested. The other methods defined in this section (c, d, e, and f) evaluate changes to the IFE monitor only. This is advantageous as one set of test results or rationale may be used to substantiate multiple integrated seat designs.

Three-point and four-point bend testing (methods d and e) only evaluates whether a revised IFE monitor design may be considered equivalent in terms of blunt trauma potential. Depending on the design change, impact testing may be required to determine if sharp edges are produced by head contact. This may be accomplished by either row-to-row seat dynamic testing, head component testing, or component impact testing. Changes to the IFE monitor weight and center of gravity are addressed using other methods.

Due to the location, construction, and material properties of each subcomponent in the IFE monitor, the appropriate assessment methods will vary depending on the area of change. Applicable assessment methods for each area of change are defined in Table 1. These assessment methods will also cover the ancillary design changes to enable the subcomponent change, such as wire routing changes, subcomponent attachment changes, etc. If an IFE monitor change does not meet the performance criteria of the simpler test methodologies (c, d, e, f), one of the seat design specific assessment methods (a or b) may be used to validate the IFE monitor change for that particular seat design.

Table 1 - Applicable assessment methods for IFE monitor subcomponent change

Area of Change	Methods	Section
Any Change (as listed below)	Row-to-row seat dynamic testing	5.1
	Head component test of the integrated seat[(1)]	5.2
Display Panel	Three-point bend test	5.3
Printed Circuit Board	Three-point bend test	5.3
	Engineering rationale (depending on change to PCB)	5.6
Touch Screen: Protective Film	Impact test, either: • Row-to-row dynamic testing • Head component test of the integrated seat • Component impact test	 5.1 5.2 5.7
	Three-point bend test	5.3
Touch Screen: Glass - Same Family	Three-point bend test	5.3
Touch Screen: Glass - Different Family	Three-point bend test and Four-point bend test	5.3 5.4
Touch Screen: Other Changes	Three-point bend test	5.3

[(1)] Does not address potential changes to HIC measurement.

The three-point bend test method and similarity criteria of 5.3 is intended for subcomponents and a general construction typical of monitors produced at the time of document publication. Designs that deviate significantly from those described in Section 3 may require additional evaluation.

Sections 5.3 and 5.4 are only applicable when the following limitations are met:

a. Seat back mounted IFE monitors only. Furniture or monument-mounted IFE monitors, or seat back designs that do not rotate forward to attenuate head impact, are out of scope.

b. IFE monitor attachments to seat structure that are located on the monitor back surface only (opposite side from the viewing screen).

c. Materials used for major internal subcomponents are not rate sensitive. For example, glass materials for this application are considered non-rate sensitive.

d. HIC results for the applicable integrated seat design:

   1. For touch screen changes, HIC results do not exceed 860.

   2. For other internal changes (display panel, printed circuit board), HIC results do not exceed 940.

   3. Test results where the monitor viewing screen was not within the primary ATD head impact load path may be excluded in the application of this limitation. For example, seat HIC tests where only the monitor shroud periphery was contacted by the ATD head.

   4. Integrated seat installations that do not require HIC to be measured are not subject to this limitation.

AIR6908 Section 4.4.4 provides background on the rationale used to define three-point bend test similarity criteria limitations.

4.1 Touch Screen

The area of change to the touch screen defines the method of testing needed to demonstrate similarity. The test methods prescribed assume no substantial changes to touch screen geometry and a protective film is part of the monitor design. If the geometry of the touch screen does change significantly or no protective film is used, head impact testing (either using a seat dynamic test, head component test device, or component test) is needed.

4.1.1 Area of Change: Protective Film

If the touch screen protective film is changed, both (1) IFE monitor impact energy attenuation characteristics for blunt trauma and (2) the potential for unacceptable post-impact sharp edges and protrusions need to be evaluated. Therefore, both an impact test and a three-point bend test shall be performed.

4.1.2 Area of Change: Glass - Same Family

If the glass inside the touch screen is changed but the replacement glass still belongs to the same family of glasses, three-point bend testing of the monitor is needed to assess similarity between the two monitor configurations. In order for glasses to be considered part of the same family, their underlying chemistries must be similar and any methods used to toughen the glass must also be similar. As such, all ionically toughened alkali-aluminosilicate glasses can be considered part of a single family, while all thermally tempered soda-lime glasses are part of a different family.

4.1.3 Area of Change: Glass - Different Family

If the glass inside the touch screen is changed and the replacement glass no longer belongs to the same family of glasses, both three-point bend testing (of the IFE monitor) and four-point bend testing (of the glass material) are needed to assess similarity between the two monitor configurations. The four-point bend test of the touch screen glass material can be used to prove that the different glasses have a similar stiffness. Then the overall stiffness of the monitor can be evaluated with the three-point bend test.

4.1.4 Area of Change: Other Changes

Other small changes to the touch screen can be evaluated using the three-point bend test of the IFE monitor.

4.2 Display Panel

A display panel change may have an effect on the IFE monitor impact energy attenuation characteristics and must be examined to demonstrate similarity. Since the display panel is typically not an exposed surface and does not function to retain fragments after impact, a display panel change does not require additional data for addressing post-impact sharp edge concerns. Therefore, three-point bend testing of the IFE monitor is sufficient for assessing display panel changes.

4.3 Printed Circuit Board

Changes to a printed circuit board (PCB) are commonly small parts (e.g., resistors or capacitors) that typically do not have a noticeable effect on either the IFE monitor's impact energy attenuation characteristics or its propensity to generate sharp edges. Therefore, changes to a PCB may be acceptable by engineering rationale (see 5.6).

If engineering rationale is insufficient, the PCB change may be assessed by performing a three-point bend test on the IFE monitor (see 5.3), as the PCB is typically not an exposed surface.

5. ASSESSMENT METHODS

5.1 Row-to-Row Dynamic Testing

Any IFE monitor change may be validated by performing row-to-row dynamic testing as described in AS8049. Additional guidance for this testing can be found in AC 25.562-1B, Change 1.

Results from this testing may be used to substantiate an IFE monitor change for both blunt trauma to the head (HIC ≤ 1000) and post-impact sharp edge aspects for that particular integrated seat design only. The ATD head must impact the IFE monitor to evaluate the seat back or seat furniture with the revised IFE monitor installed. Typically, only a “Zone C” row-to-row test configuration is needed in evaluating a monitor change, as this usually results in a head impact where a significant portion of the impact load is transferred through the monitor, whereas the “Zone A” and “Zone B” test configurations result in head impacts that do not contact the monitor or where the impact load is shared between the monitor and surrounding structure.

5.2 Head Component Testing

IFE monitor changes where the generation of post-impact sharp edges or non-HIC blunt trauma need to be assessed can be done by impact testing using a headform test device. One test is typically sufficient to evaluate the seat back with the revised IFE monitor installed. An example test is shown in Figure 3. The testing definition and evaluation criteria provided in this section are based on the guidance contained in FAA policy memorandum ANM-03-115-31.

Figure 3 - Head component testing of an integrated seat back

5.2.1 Test Device

Two devices may be used: an inverted pendulum called a Head Component Test Device (HCTD) or a free motion headform (FMH) typically used in the automotive industry. Electronic instrumentation shall be accomplished in accordance with SAE J211-1. If required, accelerations shall be measured in accordance with the requirement of Channel Class 1000.

5.2.1.1 Head Component Test Device

The head component test device is an inverted pendulum with a neck and head from a 50th percentile male Hybrid II anthropomorphic test device (ATD) mounted at the free end. An example inverted pendulum construction is shown in Figure 4, with dimensions defined in Table 2.

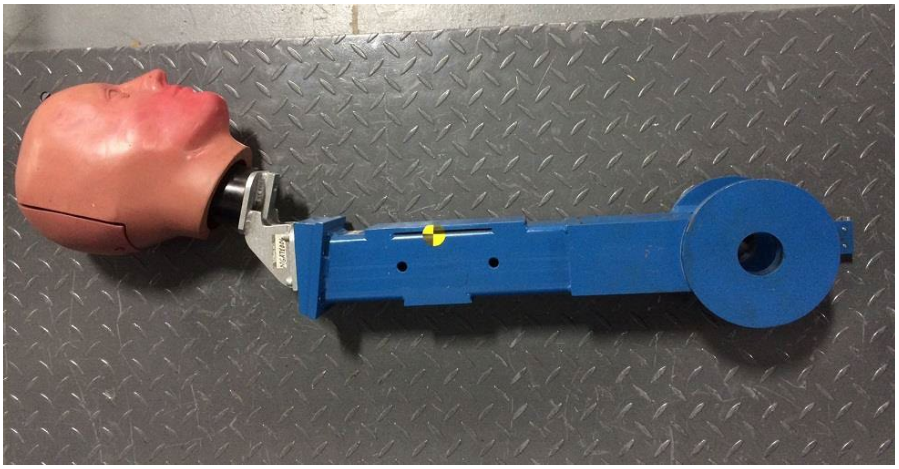

Figure 4 - Head component test device inverted pendulum example

Table 2 - Inverted pendulum measurements (example)

Item	Measurement	Notes
Pendulum Length	32.75 inches (83.19 cm)	Arm = 19.25 inches and Headform = 13.5 inches
Pendulum Mass	43.5 pounds (19.7 kg)	Arm including triaxial accelerometer pack
Center of Gravity	• 0.375 inch, back from front of arm (9.5 mm) • 6 inches, down from base of neck (152.4 mm)	

5.2.1.2 Free Motion Headform (FMH)

FMH device is defined in 49 CFR Part 572 subpart L.

5.2.2 Test Articles

5.2.2.1 Seat

Seat test articles shall be representative of the production configuration. Details of what a representative seat test article consists of for this test are as follows:

a. The seat frame (legs, fittings, beam, and such) does not have to be of a production configuration, unless the frame component is part of the articulation or energy attenuation function of the seat back assembly. For example, the seat back could be mounted to an "iron" seat frame as long as the seat back, pivoting mechanism, and energy attenuating features are correctly located relative to each other.

b. Acceptable missing components are those not in the head impact zone or do not contribute to the seat back behavior under head impact conditions, such as:

1. Instruction or safety placards.

2. Seat belts.

3. Under-seat electronic boxes.

4. Shrouds and cables.

5. Electronic components not installed on seat back assemblies.

6. Life-vest boxes and life vests.

7. Literature pockets (if outside of the head impact zone).

8. Bottom cushions and bottom cushion supports.

9. Armrests and armrest-type consoles.

10. Seat back mounted reading lights, privacy dividers, etc., outside the impact area, not contributing to strength or stiffness of the seat back or installed on the opposed side of the seat back may be replaced by ballast.

c. The following components are required for proper seat back mass distribution:

1. Headrests.

2. Seat back cushions and dress covers.

3. Seat back food tables.

4. Seat back IFE components outside the targeted head strike location, only if they might have an influence on the behavior of the backrest or the targeted head strike location. As an example, a handset and cradle located directly below a targeted IFE monitor could be sharing a load path with the monitor installation and therefore should be included in a component-level head impact test or replaced with parts shown to create a conservative test condition. Otherwise, they might be replaced by ballast, and if they are very lightweight items, they may be omitted altogether. For example, a pop-in inch-sized USB port weighing a few ounces installed well away from the head impact area would not be required to be installed on the test article.

d. Required production components are those that are either in the head impact zone or contribute to the seat back behavior under head impact conditions, such as:

1. Back frame and supports.

2. IFE components to be evaluated and their associated supporting brackets and connectors that can create a load-bearing path. Non-functional production parts and parts acceptable for HIC dynamic testing are acceptable IFE component configurations for testing.

3. Hardware and mechanisms that attach the back structure to the seat base frame.

4. Fairings, bezels, and other decorative items around the head impact area.

NOTE: Ballast may need to be added to the seat back structure to maintain seat back mass, c.g., and head impact properties. Ballast is not required to reach the seat's production weight. Also, the color of shrouding or dress cover may vary as color changes have no effect on the test outcome.

5.2.2.2 IFE Monitor

The revised IFE monitor configuration shall include any connectors that protrude from the monitor's back face, such as a D-sub connector. The connectors shall be representative of the production configuration since connectors can create a load-bearing path between the IFE monitor and seat back.

5.2.3 Test Parameters

5.2.3.1 Head Component Test Device

The head component test is performed using the test parameters defined in Table 3 and illustrated in Figure 5.

Table 3 - Head component test device - test parameters

Parameter	Setting
Impact Velocity	34 ft/s (10.4 m/s) minimum
Impact Location	Center of IFE monitor viewing screen
Impact Angle	ATD forehead initial point of contact, with impact angle as perpendicular to target without nose making contact first.

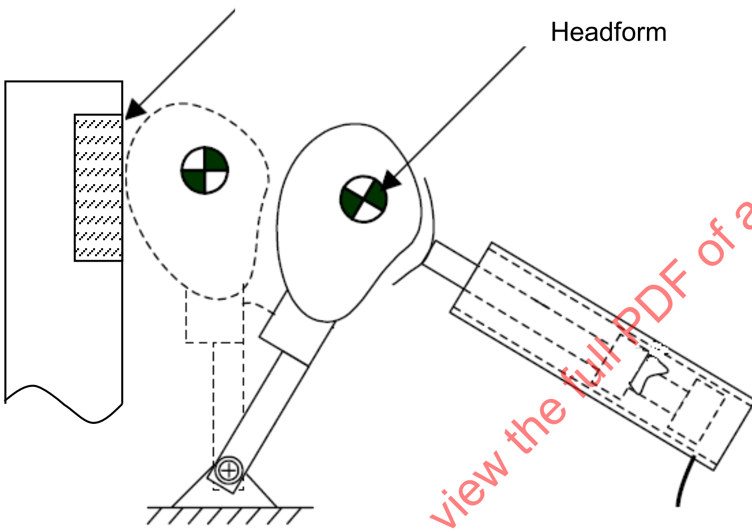

Figure 5 - Head component test impact location and orientation

5.2.3.2 Free Motion Headform

The head component test is performed using the test parameters defined in Table 4 (Test 1). If the monitor change is located around the lower edge of the monitor, or suspected of affecting how the lower edge area will withstand a head impact without generating unacceptable sharp edges, an additional test is needed (Test 2). The impact location and angle are illustrated in Figure 6.

Table 4 - Free motion headform - test parameters

Parameter	Setting
Impact Velocity	34 ft/s (10.4 m/s) minimum
Impact Location	Two locations for IFE monitors Test 1: Center of monitor viewing screen (blunt trauma and post-impact sharp edges). Test 2: Center of monitor lower edge (post-impact sharp edges only).
Impact Angle	ATD forehead impact angles Test 1: Perpendicular to monitor surface Test 2: 45-degree angle downward relative to monitor surface

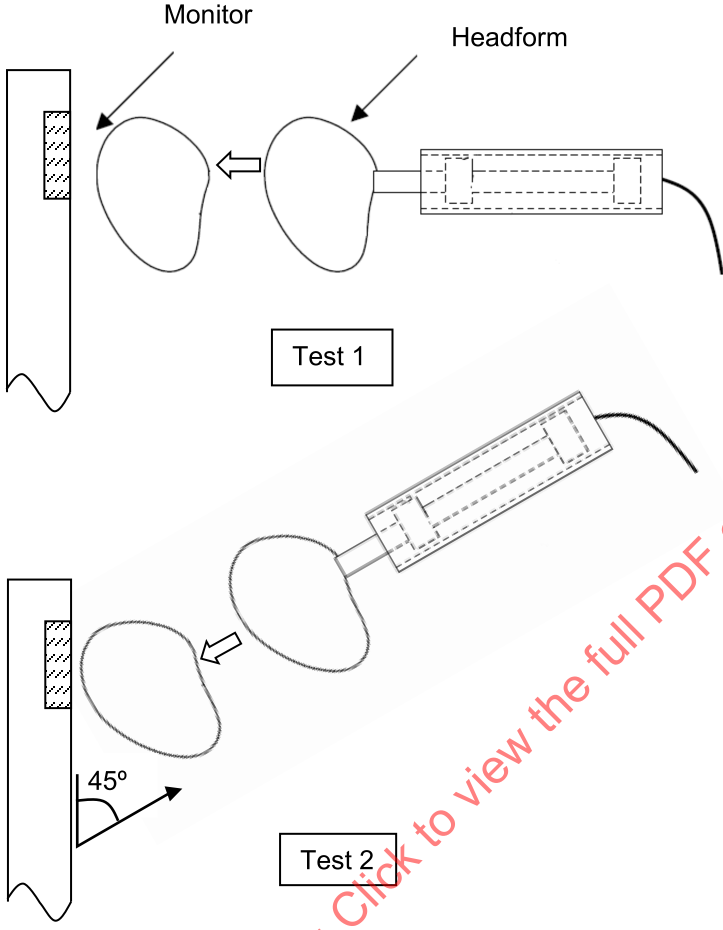

Figure 6 - Free motion headform impact location and orientation

5.2.4 Test Data

When required for evaluating blunt trauma to the head, measure head accelerations at the head center of gravity in three axes (X, Y, and Z). Inspect the IFE monitor and seat back for sharp edges and loose fragments post-test and document observations.

5.2.5 Evaluation Criteria

5.2.5.1 Blunt Force Trauma

Resultant head acceleration shall not exceed 200 g; accelerations in excess of 80 g shall not exceed a cumulative duration of 3.0 ms.

5.2.5.2 Post-Impact Sharp Edges and Protrusions

The impact shall not cause the formation of any sharp or injurious edges or features that may impede egress.

5.3 Three-Point Bend Test

A minimum of three tests shall be performed for both IFE monitor configurations (baseline and revised). More tests may be performed to improve the accuracy of the average force-displacement curves.

For the seat integrator, the baseline IFE monitor configuration is the monitor revision level to which the integrated seat was validated for acceptable head impact performance.

5.3.1 Test Method

Test parameters are defined in Table 5. The IFE monitor is placed on two simple supports, with the load applied to the center of the viewing screen. The simple supports are placed directly under the IFE monitor attachment points and run parallel with the short edges of the monitor. The load is applied until the applicator has moved a minimum of three-quarters of the monitor thickness after initial contact. Refer to AIR6908 Section 3.4 for background on the test parameters defined.

NOTE: Engineering judgment may be used to stop the test if the load goes asymptotic before the applicator has reached the minimum displacement in order to protect testing equipment.

Table 5 - Three-point bend test method

Parameter	Setting
Testing Apparatus	• Testing machine: ASTM D6272-17, Section 6.1 • Displacement measuring device: ASTM D6272-17, Section 6.3
Test Article Supports	• Cylindrical supports located at IFE monitor attachment points. Monitor simply supported (no fasteners). • Supports are longer than, and run parallel with, the short edges of the monitor. • If supports are offset, supports to be located at attachment points closest to the monitor short edges (see Figure 7). • Cylinder diameter: 0.5 to 1.0 inch (12.7 to 25.4 mm). • Cylinder material: Metal (steel, aluminum, etc.). Material shall be sufficiently rigid such that the support is not deformed (bent, flattened, or indented) as a result of test loads.
Load Rate	• <1 in/min (25 mm/min)
Load Application	• Center of viewing screen ±0.25 inch (6.4 mm) perpendicular to surface.
Load Applicator	• Applicator shape: Circular plate, between 1.5 and 2 inches (38.1 and 50.8 mm) in diameter. • Applicator material: Metal (steel, aluminum, etc.). Material shall be sufficiently rigid such that the applicator is not deformed (bent or indented) as a result of test loads. • Hard rubber pad less than 0.08-inch (2-mm) thick may be used to distribute load. Rubber material shall have a Shore A hardness between 60 to 70.
End of Test	• Either the load applicator has traveled three-quarters of the IFE monitor thickness after initial contact or the load goes asymptotic.

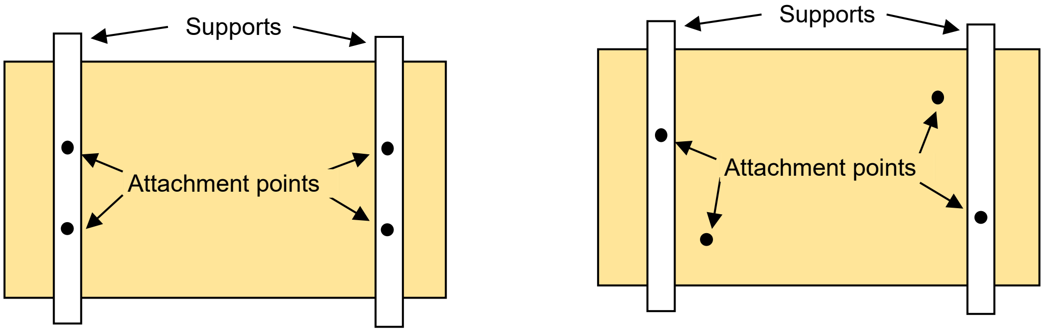

Figure 7 - Simple support placement

An example of a three-point bend test is shown in Figure 8.

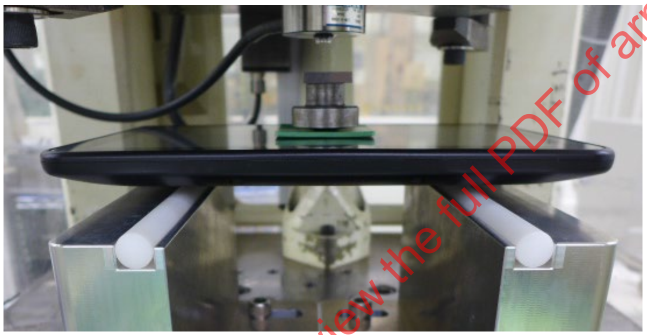

Figure 8 - Three-point bend test example

5.3.2 Test Articles

Both the baseline and revised IFE monitor configurations require testing for comparison. A minimum of three test articles per configuration are to be tested.

5.3.3 Test Data

The test data produced is the following:

a. Pretest photographs

b. Post-test photographs

c. Video of test

d. Force-displacement curve of the IFE monitor

Average the force-displacement curves for each IFE monitor configuration (both baseline and revised).

Failure at different force magnitudes is primarily due to the inherent variability of the glass materials used in the internal panels and not due to a design change. See Figure 9 for an example.

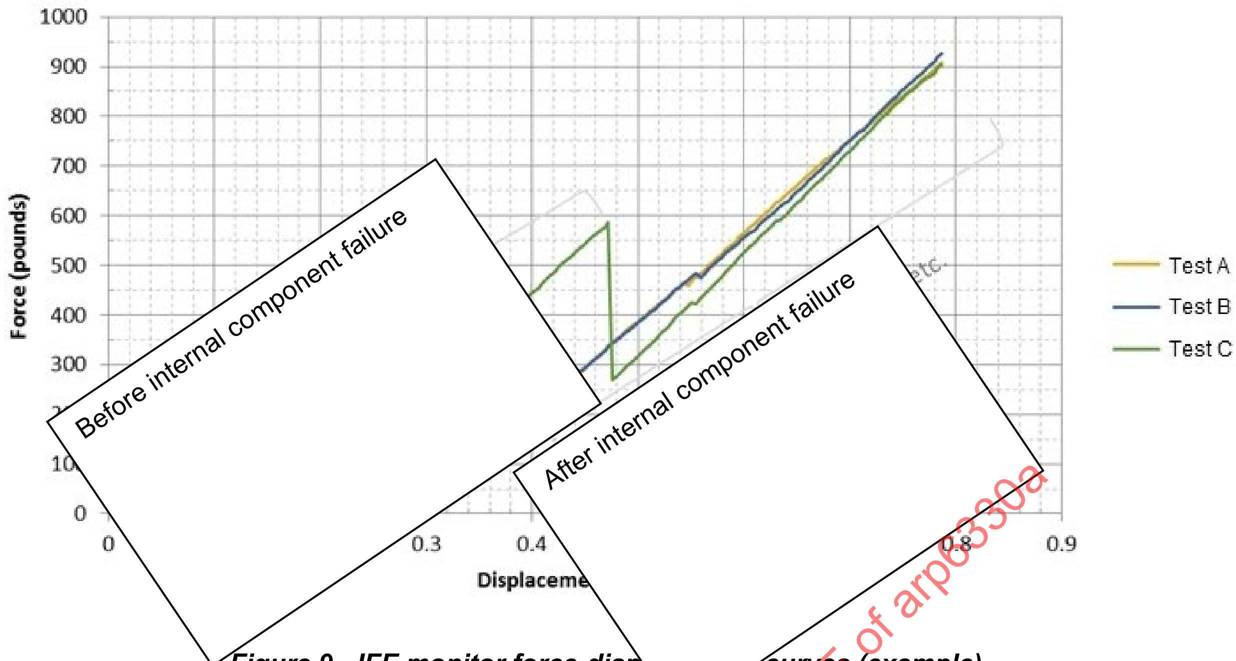

Figure 9 - IFE monitor force-displacement curves (example)

5.3.4 Similarity Criteria

The revised IFE monitor is considered similar to the baseline IFE monitor for blunt trauma based on the criteria defined in Tables 6 and 7. Refer to AIR6908 Section 4.4 for background on the similarity criteria development.

Table 6 - Similarity criteria for first part of curve (before first failure)

Parameter	Criterion
Force	Revised IFE monitor average force-displacement curve shall follow the baseline IFE monitor average force-displacement curve within ±17.5% of baseline monitor force.
Comparison Range	Start: 0.1 inch of displacement. End: Displacement of the first indicated component failure (either baseline or revised) or 0.2 inch of displacement, whichever is larger.

Table 7 - Similarity criteria for second part of curve

Parameter	Criterion
Force	Revised IFE monitor average force-displacement curve shall follow the baseline IFE monitor average force-displacement curve within +10.0% to -17.5% of baseline monitor force.
Comparison Point	Monitor at least 1-inch thick: 1/2 IFE monitor thickness. Monitor less than 1-inch thick: 3/4 IFE monitor thickness.

An example of applying the similarity criteria is provided in Figures 10, 11, and 12, using a monitor design being evaluated for a display panel change. The touch screen is unchanged, and, as expected, the force-displacement curves are the same at the start of load application. After initial subcomponent failure, the curves show more variation between the baseline and revised monitor. This variation may be due to the change in the display panel or could be due to the natural variation in the glass material. Increasing the number of test samples is an accepted method of improving the accuracy of the average force-displacement curve.

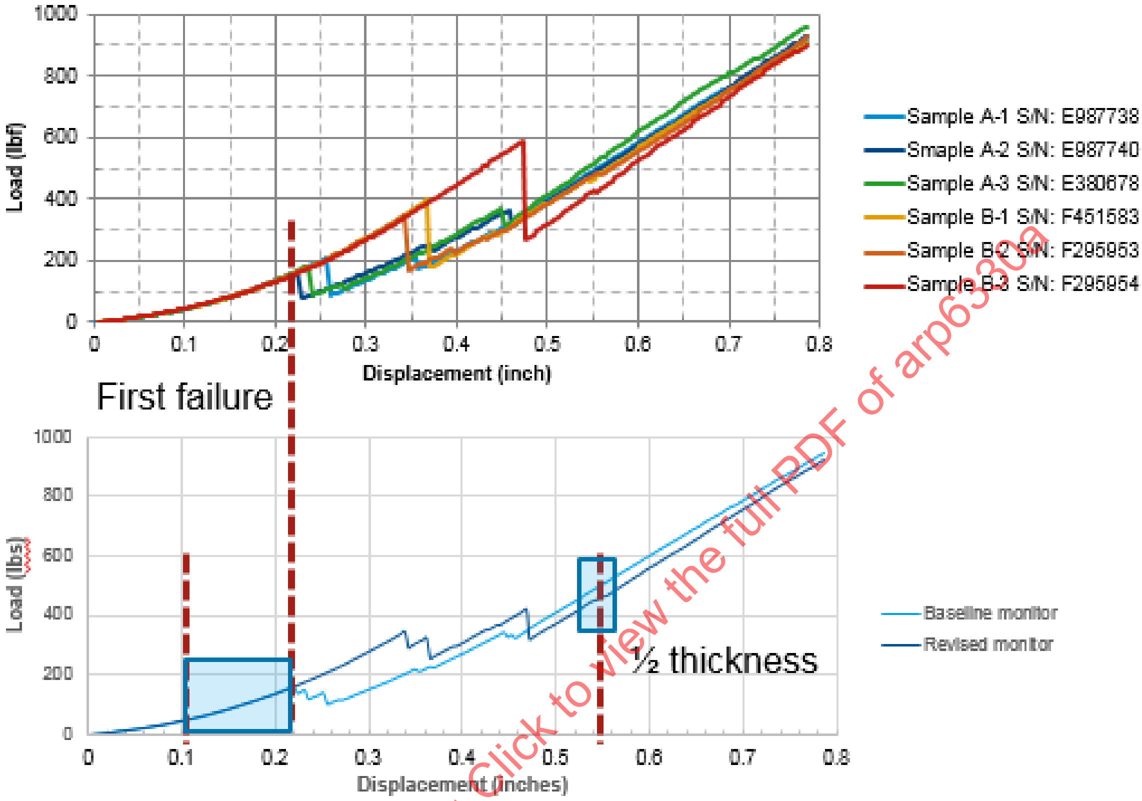

Figure 10 - Force-displacement curve comparison (example)

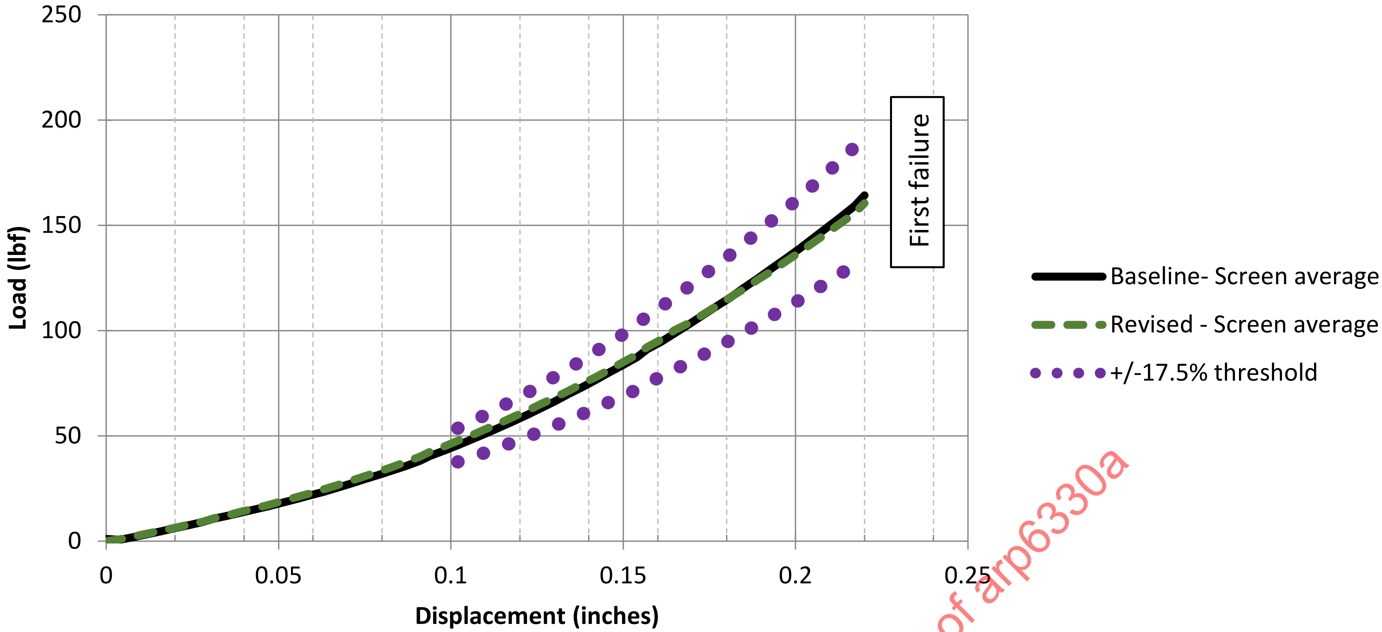

Figure 11 - Pre-failure force-displacement curve comparison (example)

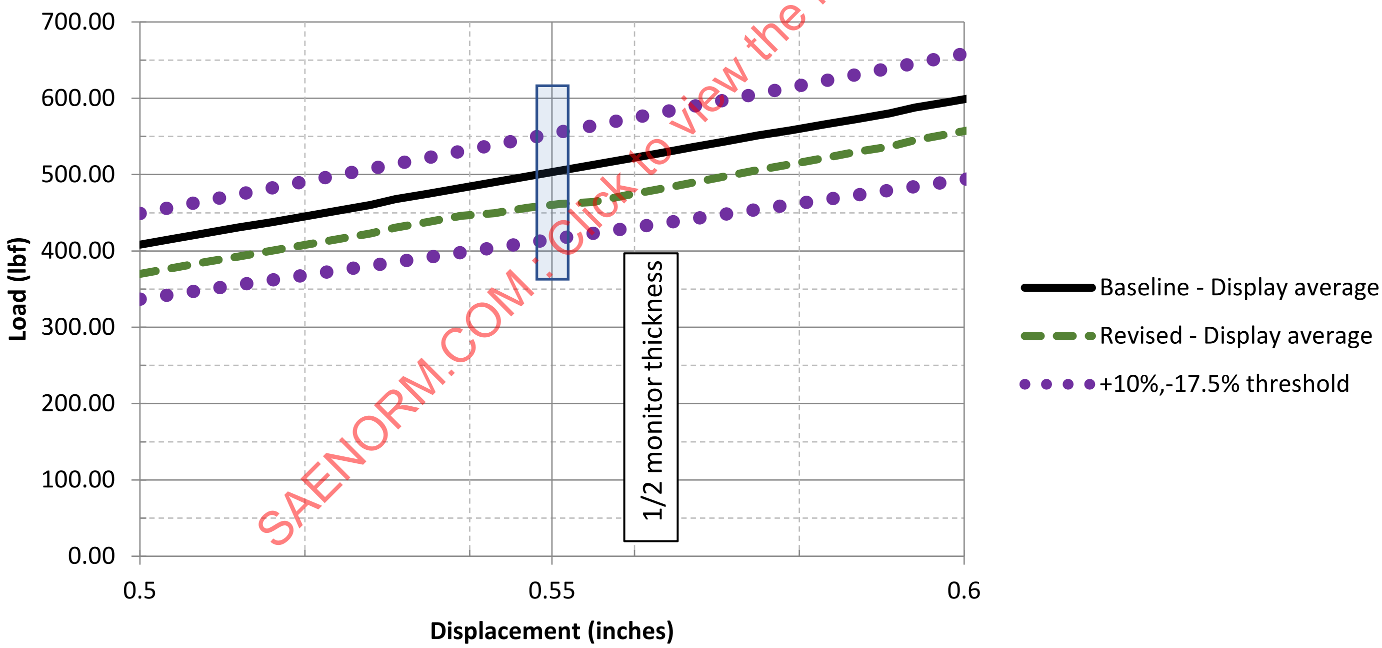

Figure 12 - Force-displacement curve comparison at half monitor thickness (example)

5.4 Four-Point Bend Test

While a three-point bend test may be done to evaluate an IFE monitor design with different glass materials, a more effective method is to directly compare the two glass materials by using a four-point bend test (see Figure 13). Refer to AIR6908 Section 3.4 for rationale in the use of a four-point bend test.

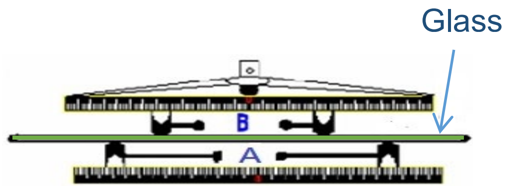

Figure 13 - Four-point bend test

5.4.1 Test Method

The four-point bend test is defined in ASTM D6272-17. Loads are applied at one-third the length of the support span and the test is performed per procedure A of ASTM D6272-17 Section 10.

5.4.2 Test Articles

Test articles shall be prepared per Section 7.2 and Section 9 of ASTM D6272-17. Each glass material shall be tested a minimum of 11 times.

5.4.3 Test Data

The test data produced is a force deflection curve of the glass material. Tangent modulus of elasticity shall be calculated per Section 12.9 of ASTM D6272-17.

5.4.4 Similarity Criterion

The calculated tangent modulus of elasticity values for each glass material shall be averaged. The average tangent modulus of elasticity of the revised glass material shall not vary from the average tangent modulus of elasticity of the baseline glass material by more than 30%.

5.5 Four-Point Bend Test - Touch Screen

An effective method to directly compare two touch screen material stack-ups is using a four-point bend test (see Figure 13).

5.5.1 Test Method

The four-point bend test uses ASTM D6272-17 as a guideline. Loads are applied at one-third the length of the support span. Rate of load application is <1 in/min (<25 mm/min).

5.5.2 Test Articles

Due to difficulty in cutting intact test specimens out of touch screens due to their use of tempered or strengthened glass, the entire touch screen shall be used as the test article. A minimum of five touch screens per configuration are to be tested.

5.5.3 Test Data

The test data produced is a force deflection curve of the touch screen. Tangent modulus of elasticity shall be calculated per Section 12.9 of ASTM D6272-17.

5.5.4 Similarity Criterion

The calculated tangent modulus of elasticity values for each touch screen shall be averaged. The average tangent modulus of elasticity of the revised touch screen shall not vary from the average tangent modulus of elasticity of the baseline design by more than 30%.

5.6 Engineering Rationale

In many instances, changes to an IFE monitor do not have an appreciable effect on the monitor's response to a head impact or overall seat performance. Therefore, a reasoned technical argument can be made to justify acceptance of the change. Rationale guidelines for various monitor attributes are provided below. A more detailed guide in the application of engineering rationale for some of these attributes is provided in Appendix A. Examples of using engineering rationale are provided in Appendix B.

5.6.1 Strength of Attachment to Seat or Seat Furniture Structure

See Appendix A for a more detailed guide in applying engineering rationale.

5.6.2 Monitor Mass and Center of Gravity

Typically, changes to the monitor have no appreciable effect on monitor mass or center of gravity. New monitor mass and center of gravity may be documented to demonstrate this evidence.

5.6.3 Post-Impact Sharp Edges (Delethalization)

The focus is on monitor external surfaces, such as shrouding, and features that encapsulate any broken internal pieces, such as shrouding and the touch screen protective film or lens (see Figures 1 and 2). Changes in monitor external surfaces can be difficult to evaluate using engineering rationale without some sort of impact data and therefore may require another method to evaluate the effect of the change. A more detailed guide in the application of engineering rationale is provided in Appendix A.

5.6.4 Flammability

These types of internal monitor changes are typically substantiated using a small part rationale (refer to ARP5526), metallic parts rationale, or located within an enclosed area. Wiring changes or changes that do not meet the means mentioned may need a more substantial flammability assessment.

5.6.5 Head Impact Criterion (HIC)

It is important to focus on the effect of the larger subcomponent (touch screen, display panel) than the change to a particular material layer. An alteration in properties for an adhesive or plastic film might be significant for the material, but the overall change in stiffness for the entire subcomponent stack-up may be negligible (and therefore acceptable). Changes to the chemical or mechanical properties of a glass layer, which typically provide the majority of the subcomponent thickness and stiffness, would likely require another method to evaluate the change. A more detailed guide in the application of engineering rationale is provided in Appendix A.

5.6.6 Seat Lumbar Performance

Monitor changes have no effect on seat lumbar performance, as monitors are not mounted under the seated occupant.

5.6.7 Monitor Abuse and Airplane Load Substantiation

Engineering rationale can be utilized if the change does not reduce the overall strength of the monitor construction.

5.7 Component Impact Test

This test method is to assess whether a seat back monitor modification has degraded the monitor's ability to withstand head impacts without generating unacceptable sharp edges or loose pieces (frangibility). The goal is to test the revised monitor at or beyond the severity level experienced when installed on a seat design.

Two approaches can be used in determining the impact severity level needed to validate the monitor design change. The first is basing impact severity for the revised monitor on current monitor impact performance. The second is to compare the severity of the test impact with the head impact severity of the current monitor installation on a seat.

5.7.1 Comparison to Current Monitor Design

This approach depends upon testing the current monitor until there are two impacts defined: one where the current monitor performs unacceptably, and the second impact with a lower impact severity where the current monitor does not have unacceptable sharp edges or loose pieces. Test the revised monitor to the second impact severity. If the revised monitor sufficiently withstands the impact, the monitor change can be substantiated for frangibility.

A pictorial view of this approach is shown in Figure 14. The first test with the current monitor design is tested at a conservative impact severity, which will likely fail the monitor. Subsequent tests are done at a reduced severity (likely with a lower impactor velocity) until the current monitor design demonstrates an acceptable post-test condition. This sets the test parameters for the revised monitor.

The testing sequence can be reversed to start at a lower impact energy initially and increase the impact severity until the current monitor demonstrates an unacceptable post-test condition. The test parameters of the impactor test with the highest impact severity that had the monitor demonstrate an acceptable post-test condition would set the test parameters for the revised monitor.

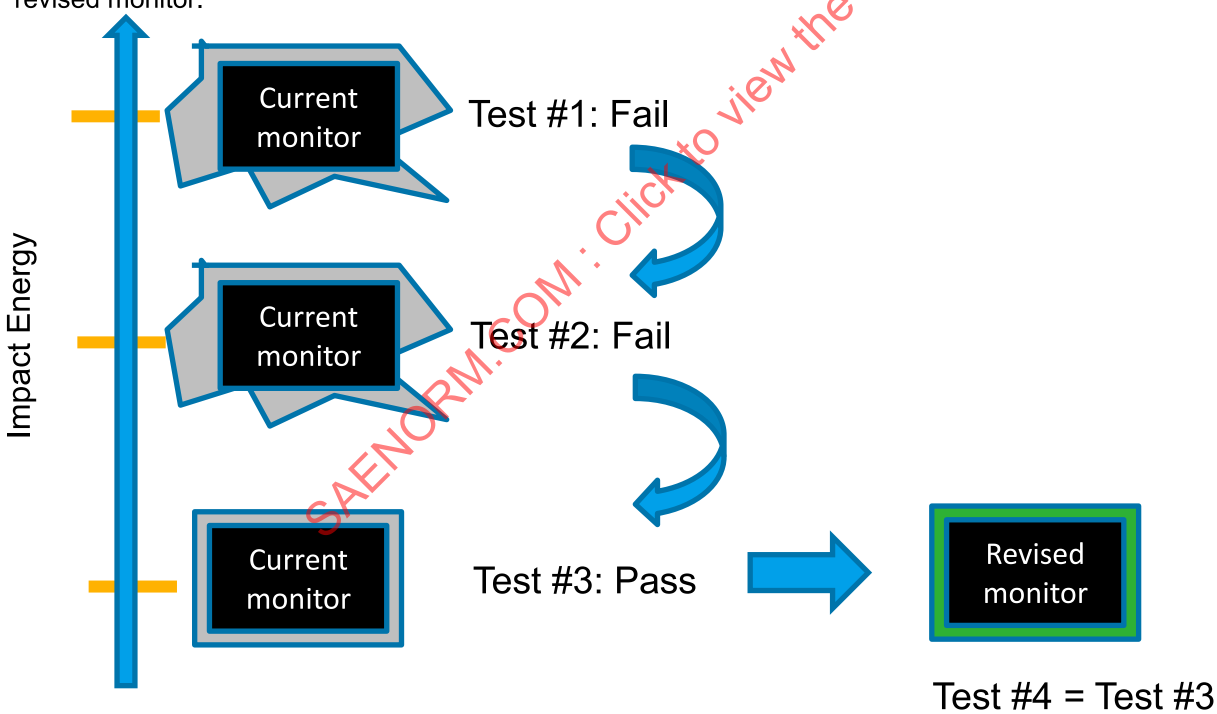

Figure 14 - Comparison between monitor revisions

5.7.2 Comparison to Current Monitor Installations

This approach is to measure the energy attenuated by the monitor during the impactor test and to compare the attenuated energy with the contribution the monitor makes in the energy attenuation of the entire seat back during a HIC test. If the monitor attenuates more energy in the impactor test than during HIC testing of the integrated seat, and the monitor does not exhibit unacceptable sharp edges or loose pieces in the impactor test, the monitor change can be substantiated for frangibility for that seat design.

A pictorial view of this approach is shown in Figure 15, with the revised monitor design initially tested at a very conservative impact severity and with subsequent tests at a lower severity (likely with a lower impactor velocity) until the revised monitor design demonstrates an acceptable post-test condition. This then defines the monitor energy attenuation during the impactor test that is compared to the monitor's energy attenuation contribution to applicable integrated seat designs. Note that the testing sequence can be altered to test at a lower impact energy initially, and increase the impact severity until the monitor demonstrates an unacceptable post-test condition. The test parameters of the impactor test with the highest impact severity that had the monitor demonstrate an acceptable post-test condition would define the energy attenuation value to compare.

The number of tests can be reduced if the monitor head impact energy attenuation contribution to the overall integrated seat design has been assessed by the use of nonlinear finite element analysis. If this is the case, the monitor can be tested at or above that known energy level.

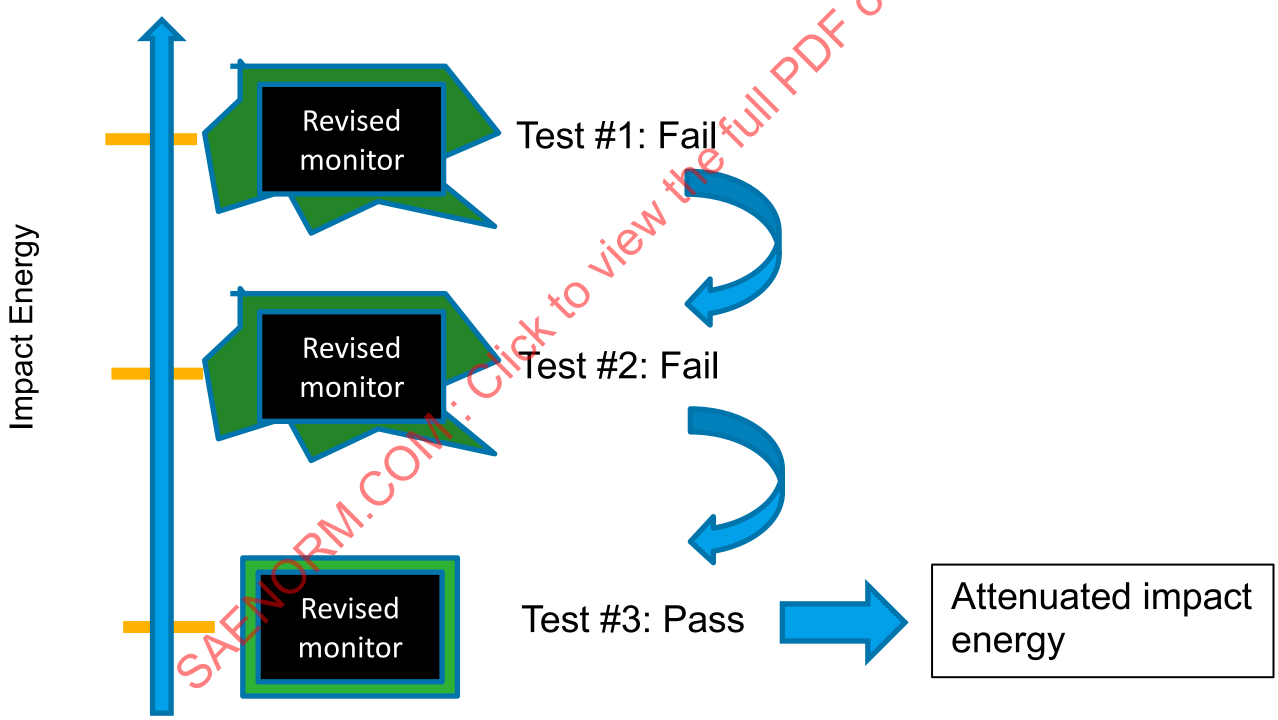

Figure 15 - Comparison of monitor impact energy attenuation (impactor versus installed)

5.7.3 Impact Testing of Monitors

5.7.3.1 Test Articles

A minimum of three test articles are to be tested at the impact energy level used for comparison.

5.7.3.2 Test Device

A linear impactor with a hemispherical end. Typically, these devices are used in testing to FMVSS 201L. See Figure 16 for a photograph of an example impactor. A linear impactor can be used for monitor comparison methods described in 5.7.1 and 5.7.2.

A pendulum-type impactor with a rounded end. One such impactor is an inverted pendulum described in 5.2.1.1. A pendulum impactor can be used only for the monitor comparison method described in 5.7.1.

5.7.3.3 Impact Test Conditions

The impact test conditions are similar to the ones defined in 5.2. However, the impact velocity may be adjusted to get the desired impact severity.

Table 8 - Impact test parameters

Parameter	Criterion
Impact Velocity	Variable, but 34 ft/s (10.4 m/s) is a conservative impact velocity to start with.
Impact Location	Design change location or area of interest. Center of touch screen is the default location.
Impact Angle	Perpendicular to monitor face.

5.7.3.4 Test Fixture

The objective of the test fixture design is to rigidly support the aluminum sheet while allowing the sheet to deform during impact without contacting other structure. The fixture parameters defined have been validated for most IFE monitor designs to meet this objective. However, fixture parameters may be modified as needed. An example of a test fixture is shown in Figure 16.

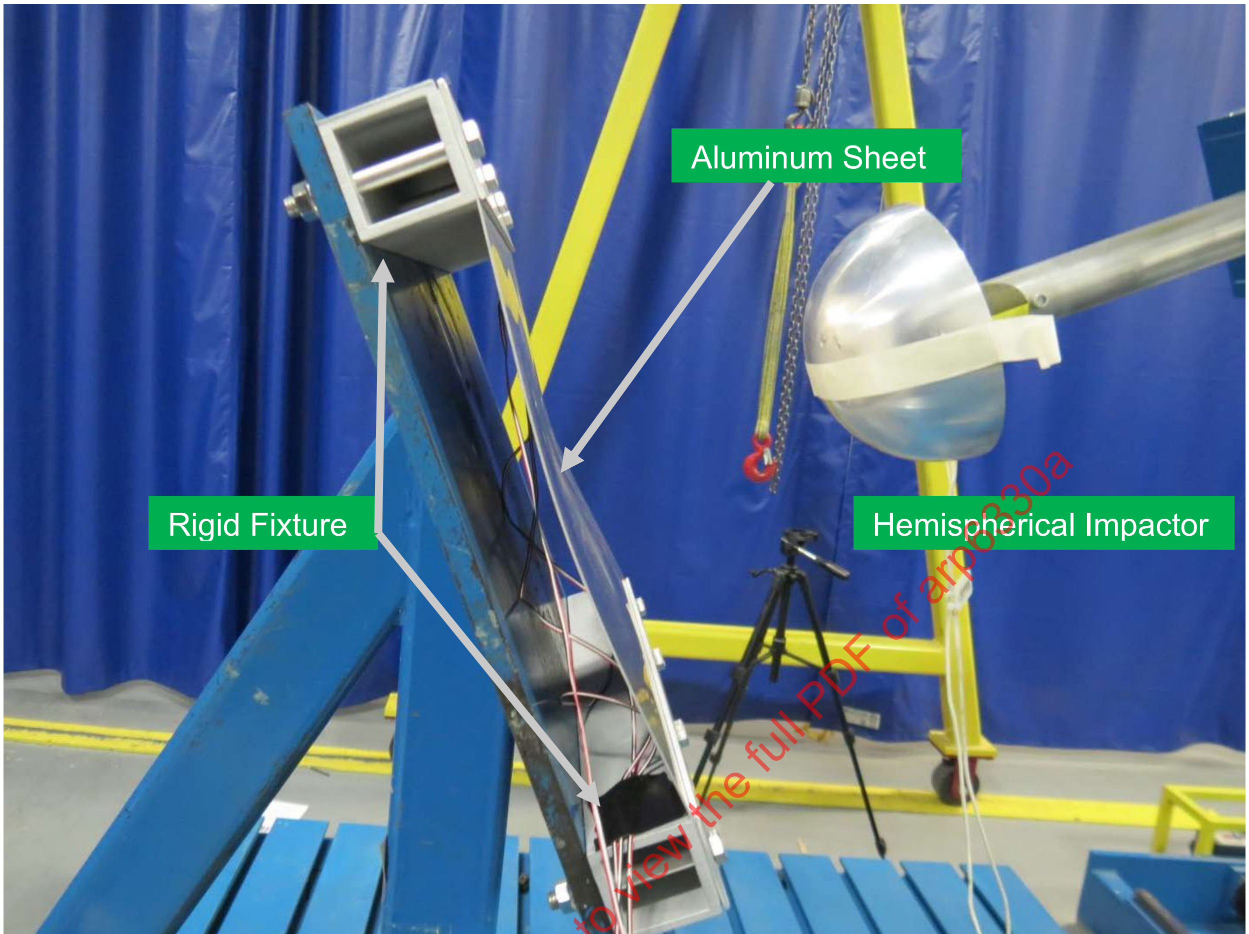

Figure 16 - Linear hemispherical test fixture

Table 9 - Component impact test fixture

Parameter	Criterion
Aluminum Sheet	• Aluminum 6061 • Minimum size is 20.5 inches by 16.4 inches (520 mm by 370 mm) but can be increased if necessary to achieve desired impactor deceleration. • Thickness may be adjusted to achieve desired impactor deceleration. Recommend starting at a thickness of 0.04 to 0.08 inches (1.0 to 2.0 mm).
Sheet Fasteners	• Minimum 3/8-inch (9.5-mm) diameter (nominal) • Plate to distribute clamping force
Test Fixture	• Made of material considered “rigid” for this application (steel, aluminum, etc.). • Large enough to provide attachment of aluminum sheet upper and lower edges up to a maximum overlap of 2 inches (50 mm) per edge. • Height of fixture: a minimum of 2 inches (50 mm) from bottom surface of aluminum sheet. Height may be increased if aluminum sheet deflection is causing the suspended aluminum sheet to contact the fixture.

The objective of the sheet to fixture attachment is so that the sheet is consistently affixed over the width of the sheet, and that during impact the sheet does not show significant deformation at the points of attachment. The goal of the test is to have the suspended portion of the sheet do the majority of attenuating the impact. Therefore, the sheet fastener hole locations, fastener details, fastener torque, fixture interface (threaded or simple holes), and other details are not specified. A plate is to be used to better distribute the fastener clamping force over the entire width of the sheet. See Figure 17 for an example test setup.

IMPORTANT: The test must not result in the aluminum sheet deflecting such that the suspended portion of the sheet contacts the test fixture during impact. If this occurs, the test is considered a null test. Further testing will need to have one or more test parameters (fixture height, impact velocity, sheet thickness, etc.) modified to eliminate the sheet-fixture contact.

If there is a concern that the sheet deflection will be large enough to contact the fixture during a planned impact test, a method to determine surface contact (such as chalk) should be used.

5.7.3.5 Test Article Support

The objective for the test article support is to be a rigid spacer between the monitor attachment points and aluminum sheet. This allows the monitor to bend aftward and minimize contact with the supporting aluminum panel.

Monitor attachment points on the monitor's aft face will vary or have multiple sets of attachment points. As with the three-point bend test of 5.3, the most conservative test condition is to maximize the suspended distance between the monitor supports. A support may be continuous between pairs of attachment points and shall run parallel with short edges of the monitor as much as possible. See Figure 17 for an example of a monitor mounted to the test fixture.

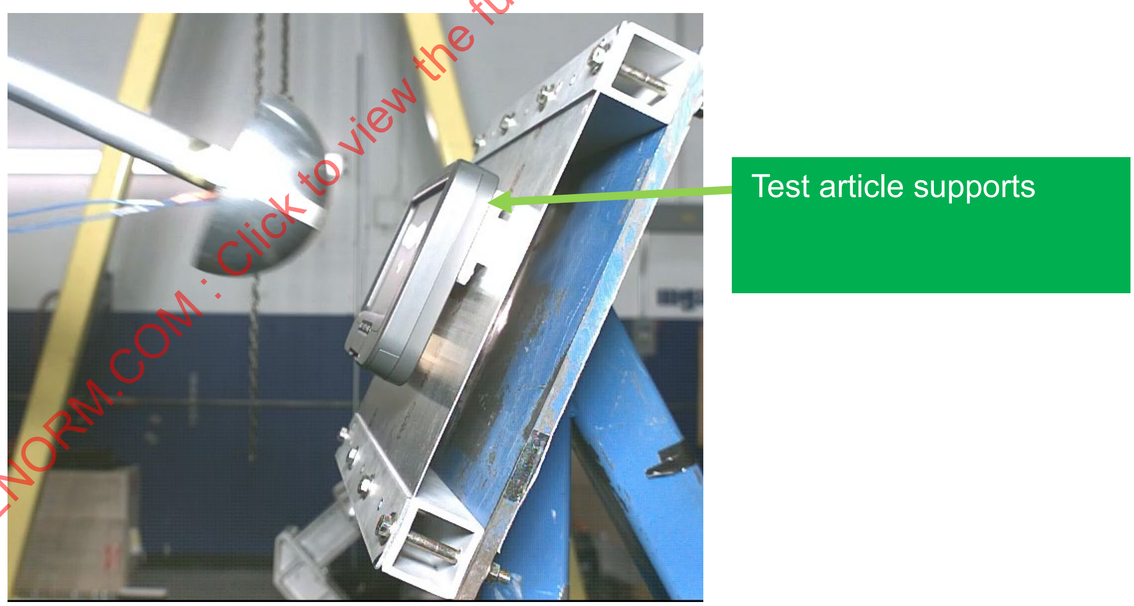

Figure 17 - Monitor mounted to test fixture

Table 10 - Test article supports

Parameter	Criterion
Test Article Supports	• Made of material considered "rigid" for this application (steel, aluminum, etc.). • Rectangular in shape, with some rounding of corners acceptable. • Height such that the monitor does not contact the aluminum sheet surface between the supports • Shall be sized such that the edge of the support is less than 1 inch (25 mm) from the center of the support's interfacing monitor attachment point, except in the direction of its associated attachment pair.
Support Mounting Location	• Supports shall be located relative to the sheet such that the center of the monitor front surface is within 0.5 inches (13 mm) of the center of the suspended portion of the sheet.
Attachment Fasteners	• Hardware used to attach the supports to the monitor shall be of equivalent or greater strength than what is specified for monitor installation. • Hardware used to attach the support to the aluminum sheet shall be of sufficient strength so that the hardware does not show permanent deformation post-test.

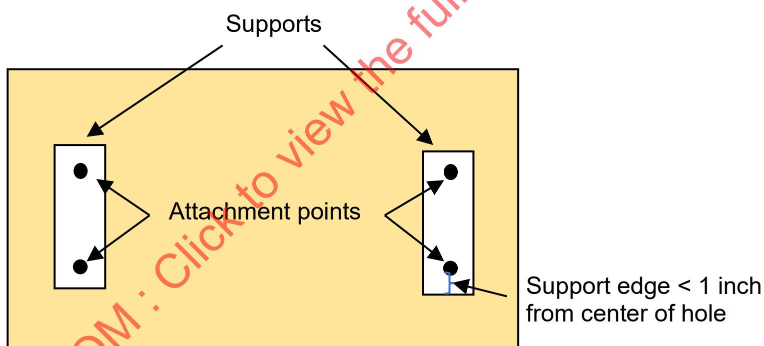

Figure 18 - Support positioning

5.7.3.6 Test Data

The test data produced is the following:

a. Pretest photographs

b. Post-test photographs of monitor, test fixture, test article supports, and any loose pieces

c. Video of test

d. Post-test observations of monitor condition (sharp edges, loose fragments, cracks, areas of delamination, etc.)

e. Post-test observations of test fixture, sheet, and attachment hardware (deformation, broken pieces, etc.)

f. Impactor acceleration in three axes (X, Y, Z) and resultant

g. Impactor energy versus impactor travel (if using a linear impactor); example provided in Figure 19

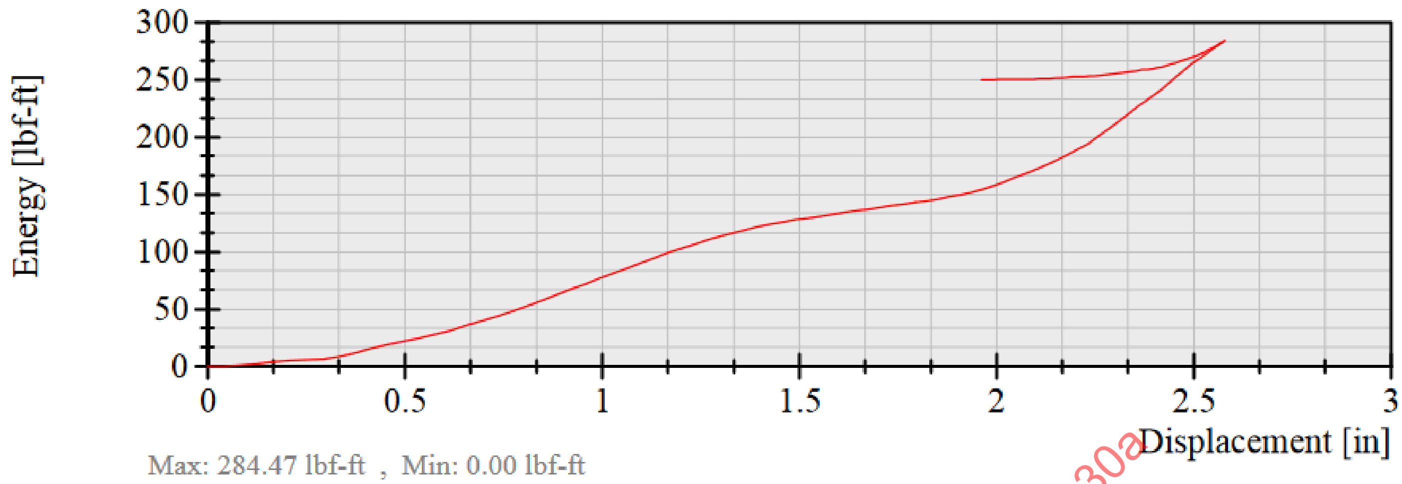

Figure 19 - Example linear hemispherical impactor energy vs. displacement curve

5.7.3.7 Test Evaluation

Review the post-test condition of the test setup for the following:

a. Significant deformation or breaking of attachment hardware.

b. Signs of fasteners shearing through the aluminum sheet. Some deformation of sheet holes is expected.

c. Signs of contact between the suspended portion of the sheet and the fixture.

5.7.4 Energy Attenuation Calculation

For the approach defined in 5.7.2, the test fixture without the monitor needs to be tested to determine the energy attenuating contribution of the fixture, which is then subtracted from the measured energy attenuation of the monitor and fixture to determine the energy attenuation contribution of the monitor.

5.7.4.1 Impact Testing of Aluminum Sheet

Test parameters shall be the same as the testing with the monitor (impactor velocity, sheet thickness, etc.) for comparison, except for the impact location, which shall target the center of the aluminum sheet. See Figure 20 for an example of an aluminum sheet only impact. One test is sufficient.

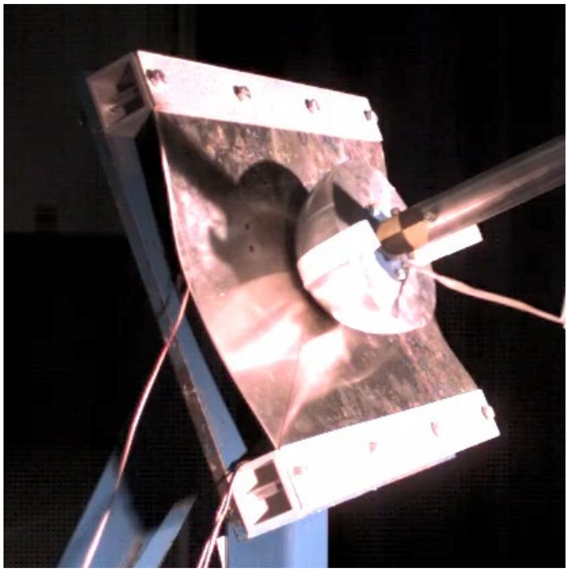

Figure 20 - Photo of aluminum sheet only impact test

5.7.4.2 Comparison of Impacts With and Without Monitor

For each impact condition (monitor and no monitor), integrate the energy versus impactor travel to the maximum impactor travel distance. Use the average from the three monitor tests. The curve with the monitor installed should have a higher number than the curve without the monitor. An example is provided in Figure 21, where the test with the monitor is 42 ft-lb-in larger than the test without the monitor.

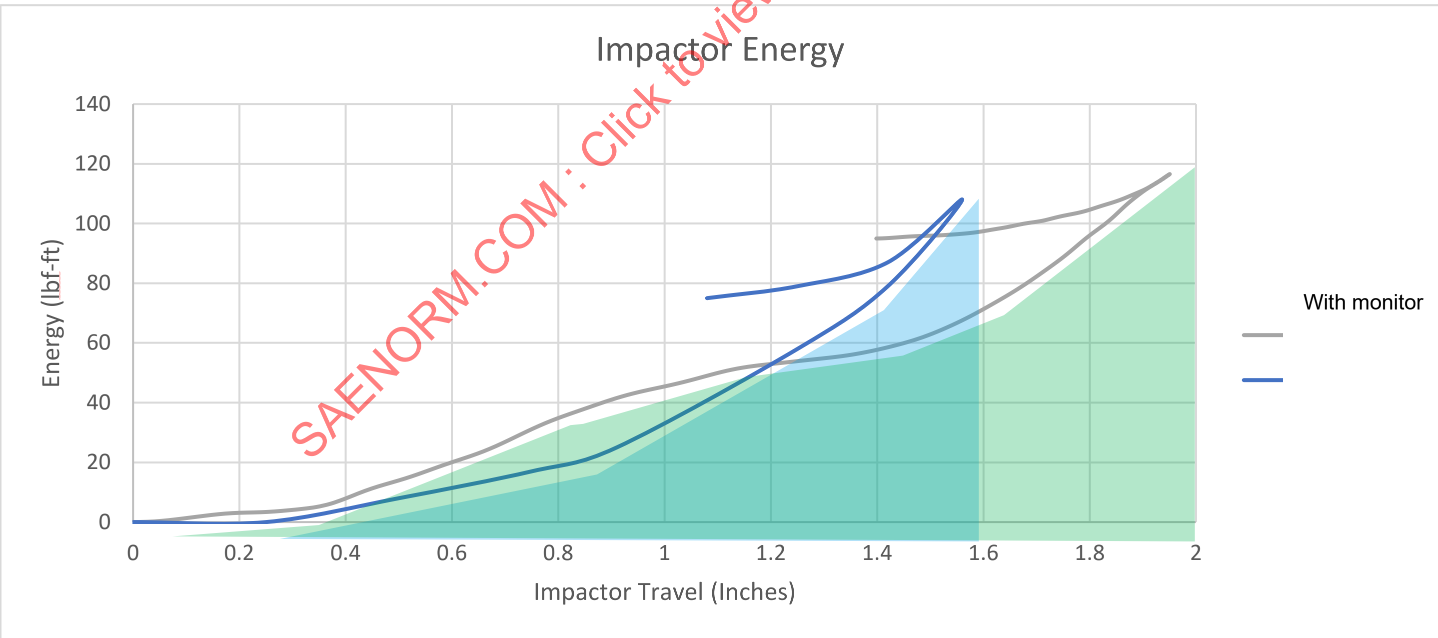

Figure 21 - Comparison of energy attenuation with and without monitor

6. USE OF MONITOR COMPONENT DATA

Changes to seat back monitor designs require coordination between the IFE manufacturer and the integrator of the IFE components on the seat, typically the seat manufacturer. More details and recommended practice for this coordination are described in ARP6448. An Electronic Manufacturer Notice of Change (EMNOC) is the primary method of communicating changes between IFE and seat manufacturers. As part of the EMNOC, the IFE manufacturer may choose to use methods defined in 5.3, 5.4, 5.6, and/or 5.7 to provide data to the seat manufacturer to assist in their evaluation of whether additional justification or data is required to substantiate the monitor change for HIC or post-impact sharp edges.

The flowchart in Figure 22 is the general flow of information and decision gates involving the IFE manufacturer and seat manufacturer in the use of monitor component data. Keep in mind the important aspect to review is how the monitor integrates into the seat structure. Significant changes to the internal construction of the monitor will drive variation in the monitor force displacement curve, thereby failing the similarity criteria.

Typically, the baseline and revised monitor configurations have the same base part number, but not always. For those situations where the revised monitor has a different base part number than the baseline monitor, verify that the following design aspects are similar between the two monitor configurations:

a. External dimensions are the same.

b. Attachment pattern on the monitor back face is similar to the baseline monitor.

c. General construction methodology.

    1. Construction (shroud, frame, layered construction, types of subcomponents, etc.)

    2. Materials (similar plastic for shrouds, frame still made of aluminum, etc.)

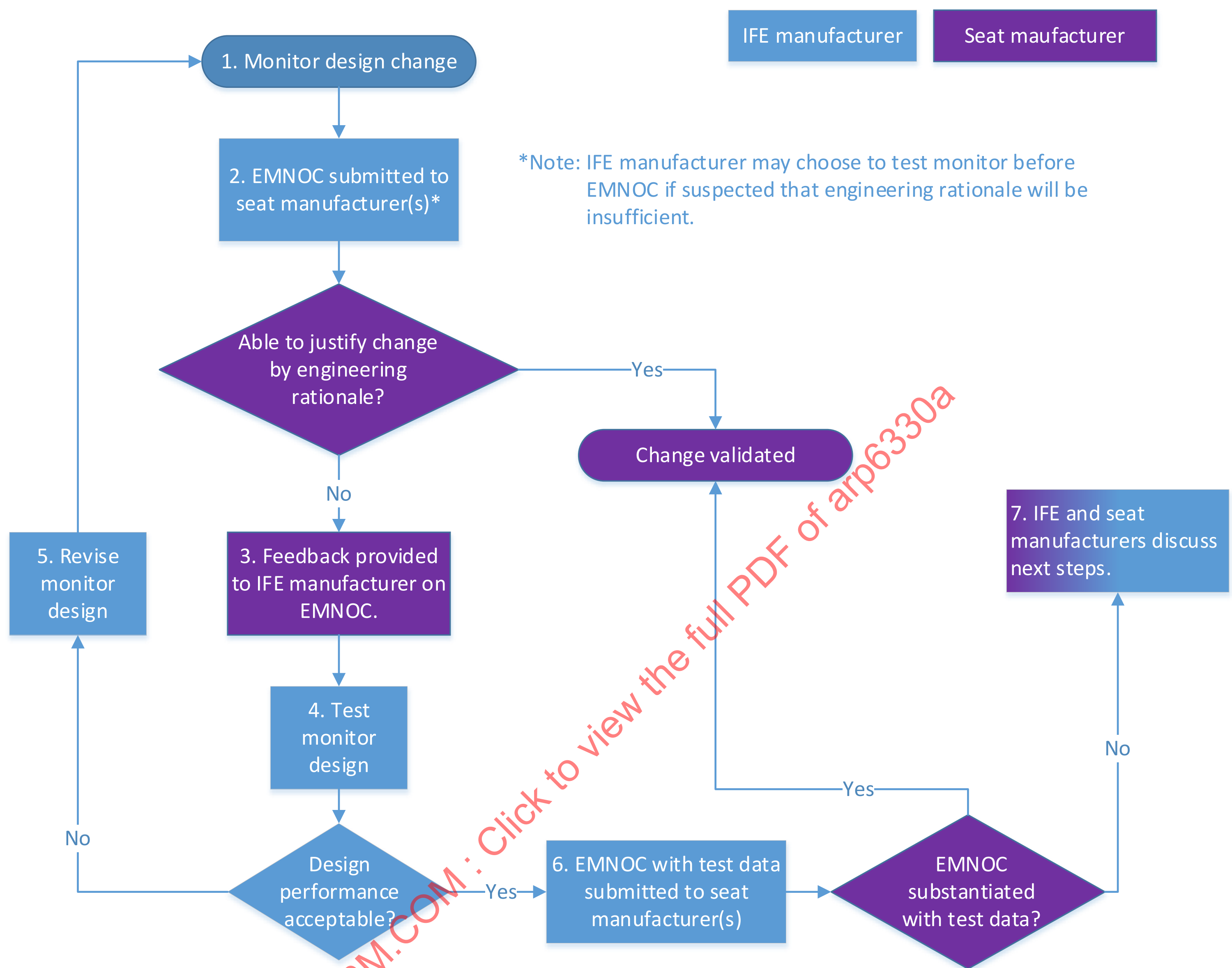

Figure 22 - Process flow of using of monitor component data

Step 1: IFE manufacturer initiates a design change to a monitor.

Step 2: The EMNOC is submitted by the IFE manufacturer to affected seat manufacturers. The IFE manufacturer may determine that an engineering rationale may not be sufficient to justify the monitor design change at the seat integration level and decide to test the revised design using methods documented in 5.3, 5.4, 5.5, and 5.7 before receiving feedback from seat manufacturers. If this is the case, skip to Step 6.

Step 3: If the provided information in the EMNOC is sufficient for the seat manufacturer to determine that the monitor change has no appreciable effect on the integrated seat, then no further data is needed and the monitor change can be approved for the seat design. If the provided information in the EMNOC is insufficient, further discussions between the seat manufacturer and IFE manufacturer are necessary. The likely situation is that engineering rationale alone is not sufficient to justify the monitor change, and the methods described in 5.3, 5.4, 5.5, and/or 5.7 will need to be applied.

Step 4: IFE manufacturer tests the monitor design per the method(s) chosen.