

THE IMPACT TESTING ENIGMA

*A Review of ASME Section VIII, Division 1, Subsection C, Part UCS,
Impact Testing Requirements*

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2.0 INTRODUCTION

Manufacturers continuously face the challenge of complying with the impact testing provisions of ASME Section VIII, Division 1.

Because the Code impact testing rules are quite complex, instances of misconception and or oversight are not unusual, hence the ¹enigma. The material provided in this part of the ABSA Manufacturer's Workshop is not intended to replace the Code rules, or the knowledge of Code rules. The intent of this review of impact testing rules and the decision charts provided is to help manufacturers meet Code requirements.

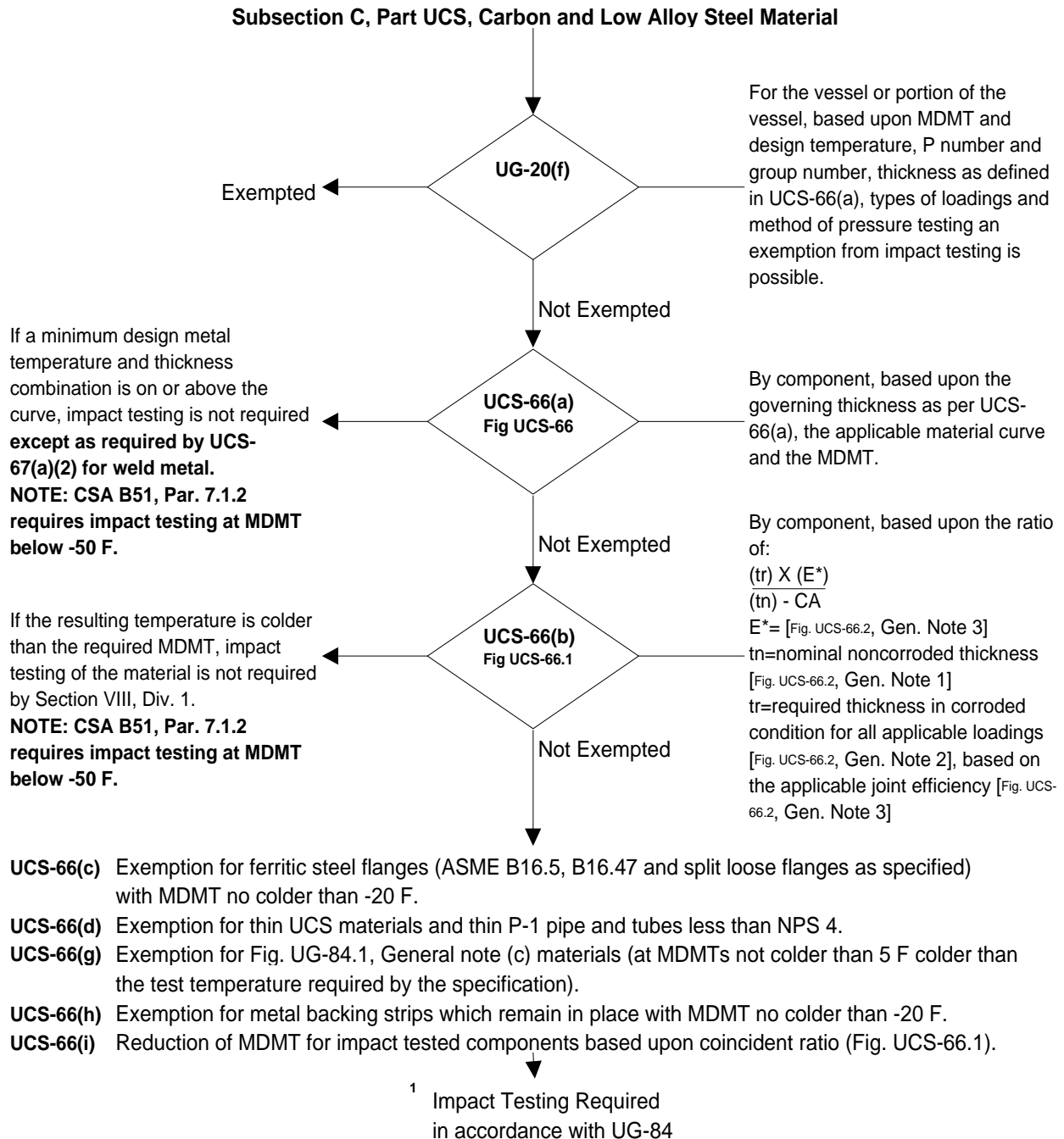
This presentation and the handout material was prepared and reviewed with the intent of full compliance with the 1998 Edition, 1999 Addenda of ASME Section VIII, Division 1. With regard to the review process, Mr. Bruce McWhirter (ABSA Design Survey Manager) must be recognized for his efforts as they were sincerely appreciated. The responsibility for any discrepancies between these documents and Code requirements is completely the author's. If discrepancies exist, they should not be misconstrued to reflect an ABSA position.

The presentation material consists of a series of impact testing decision charts, and a selection of the **most common** problems, misconceptions and oversights with regard to impact testing as it applies to pressure vessel construction to the ASME Code, Section VIII, Division 1, CSA B51 Part 1, and Alberta requirements. The primary focus of the document is on Subsection C, Part UCS impact testing requirements.

¹ In the Webster's Ninth New Collegiate Dictionary, **Enigma** is defined as "something hard to understand or explain".

3.0 IMPACT TESTING DECISION CHARTS

3.1 Impact Testing Requirements (Materials)



For the vessel or portion of the vessel, based upon MDMT and design temperature, P number and group number, thickness as defined in UCS-66(a), types of loadings and method of pressure testing an exemption from impact testing is possible.

If a minimum design metal temperature and thickness combination is on or above the curve, impact testing is not required **except as required by UCS-67(a)(2) for weld metal.**
NOTE: CSA B51, Par. 7.1.2 requires impact testing at MDMT below -50 F.

By component, based upon the governing thickness as per UCS-66(a), the applicable material curve and the MDMT.

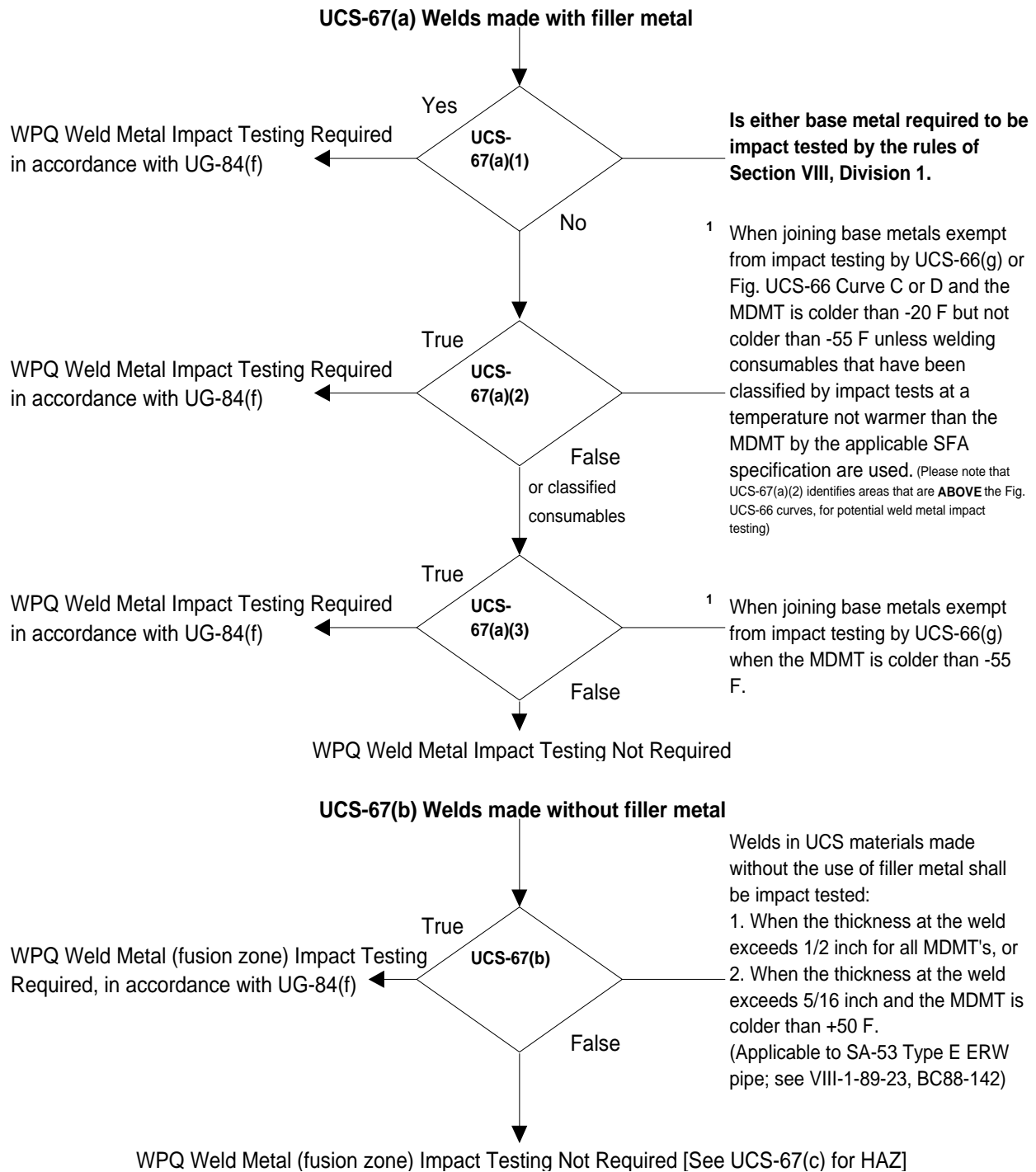
If the resulting temperature is colder than the required MDMT, impact testing of the material is not required by Section VIII, Div. 1.
NOTE: CSA B51, Par. 7.1.2 requires impact testing at MDMT below -50 F.

By component, based upon the ratio of:
(tr) X (E*)
(tn) - CA
E* = [Fig. UCS-66.2, Gen. Note 3]
tn = nominal noncorroded thickness [Fig. UCS-66.2, Gen. Note 1]
tr = required thickness in corroded condition for all applicable loadings [Fig. UCS-66.2, Gen. Note 2], based on the applicable joint efficiency [Fig. UCS-66.2, Gen. Note 3]

¹ See UCS-68(c) for further reduction in the MDMT exemption when nonmandatory PWHT is performed.
NOTE: CSA B51, Par. 7.1.2 requires impact testing at MDMT below -50 F.

3.2 Impact Testing Requirements (Welding Procedure Qualifications – Weld Metal)

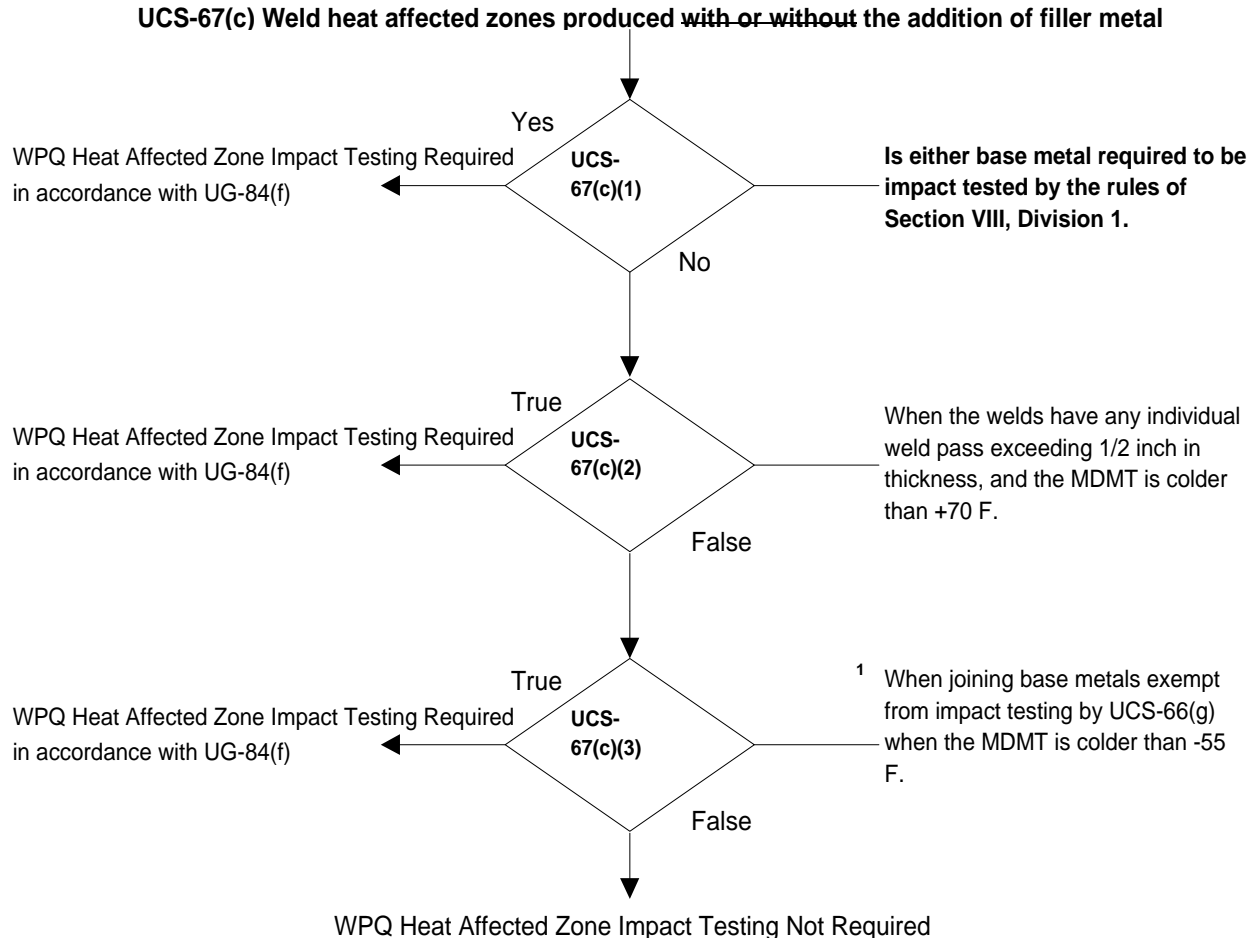
Subsection C, Part UCS, Carbon and Low Alloy Steel Material



¹ NOTE: CSA B51, Par. 7.1.2 requires impact testing at MDMT below -50 F.

3.3 Impact Testing Requirements (Welding Procedure Qualifications – HAZ)

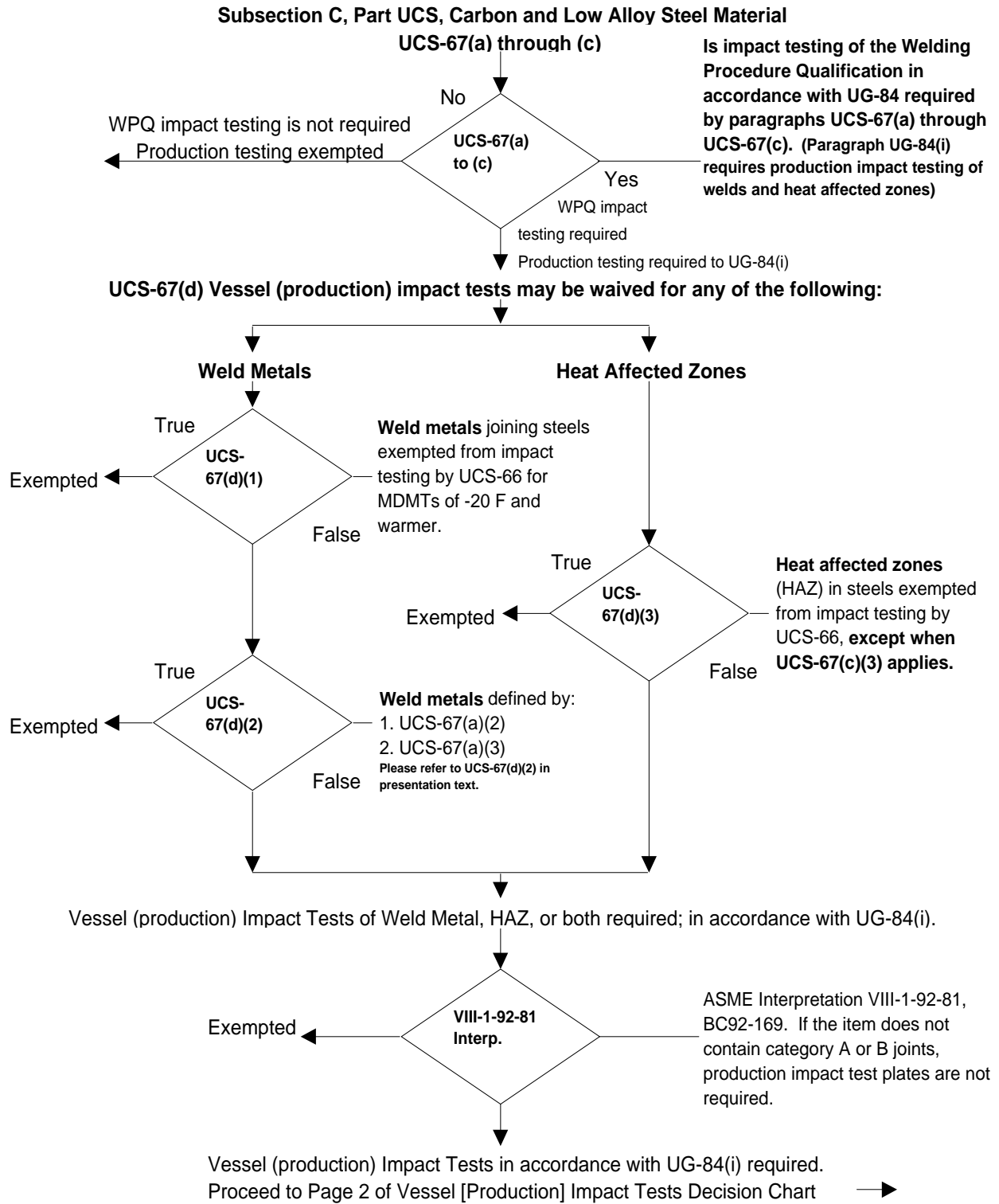
Subsection C, Part UCS, Carbon and Low Alloy Steel Material



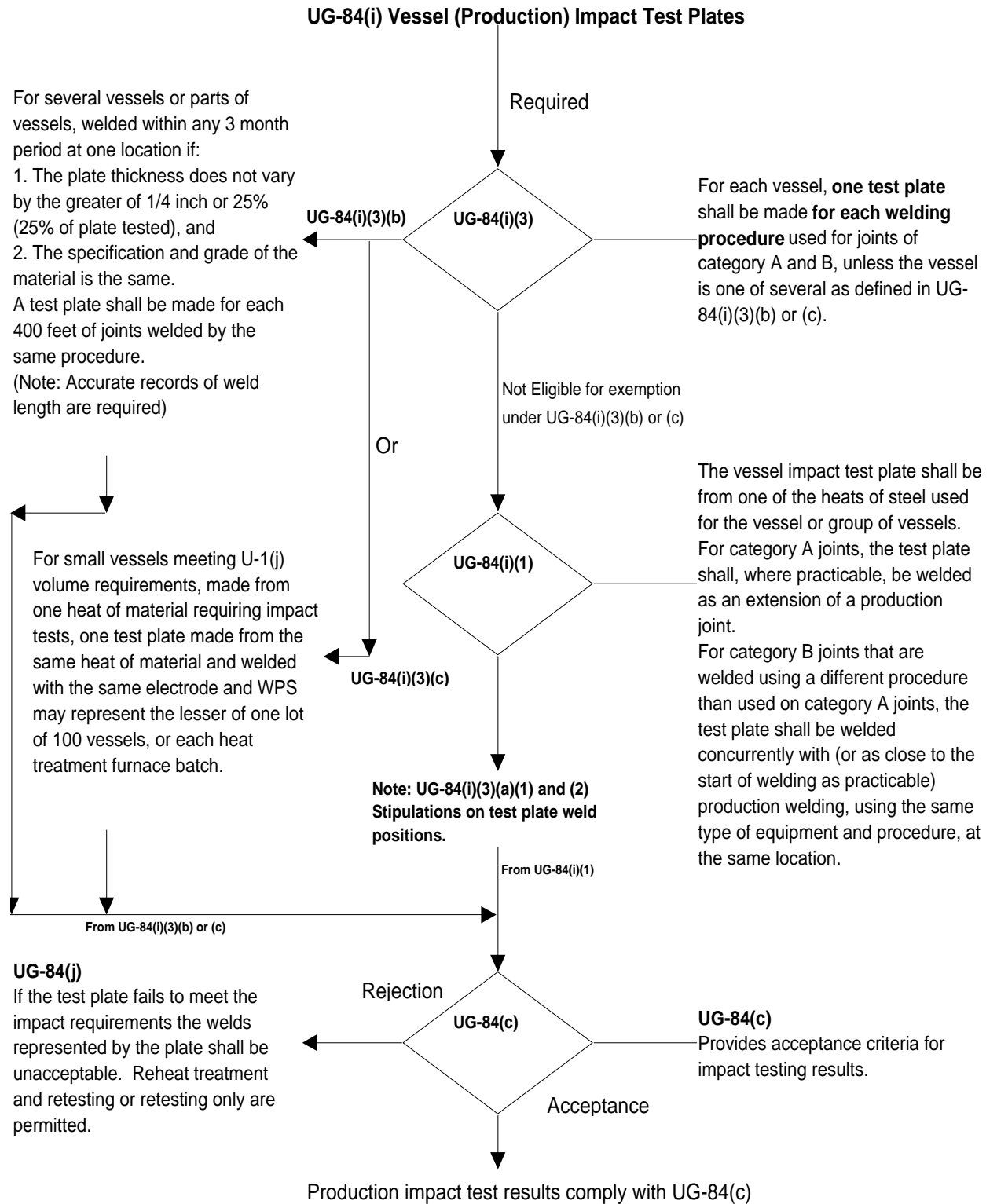
¹ NOTE: CSA B51, Par. 7.1.2 requires impact testing at MDMT below -50 F.

Prepared in accordance with ASME Section VIII, Division 1 - 98 Ed./99 Add. & CSA B51-97

3.4 Impact Testing Requirements (Vessel [Production] Impact Tests Page 1)



3.5 Impact Testing Requirements (Vessel [Production] Impact Tests Page 2)



4.0 MATERIALS & DESIGN

4.1 CSA B51-97, Part 1, Clause 7.1.2

Carbon steel used for the construction of pressure vessels at a minimum design temperature below -50°F shall be impact tested.

4.2 UG-20(f)(1)

To qualify for exemption under UG-20(f) the material shall be limited to P Number 1, Group Number 1 or 2, and **the thickness as defined in UCS-66(a)** is limited to $\frac{1}{2}$ inch for curve A materials and 1 inch for curve B, C, or D materials.

4.3 UCS-67(a)(2)

Under the provisions of UCS-67(a)(2), for MDMTs that are colder than -20°F but not colder than -55°F , **areas above curves C and D are identified in addition to materials produced and impact tested in accordance with the requirements of the specifications listed in Fig. UG-84.1 General Note (c)**. When the welding consumables used to join these base metals have not been classified by impact tests at a temperature not warmer than the MDMT, the welding procedure qualification shall include impact tests of welds and heat affected zones, as specified by the first paragraph of UCS-67.

4.4 UCS-68(b)

This paragraph requires that welded joints be postweld heat treated when required by other rules of Section VIII-1 or when the MDMT is colder than -55°F , and the coincident stress ratio as defined in Fig. UCS-66.1 is 0.35 or greater.

4.5 Exemption Combinations

3.5.1 Interpretation VIII-1-89-138R

If a vessel is constructed of a combination of P-No. 1 Group No. 1 or 2 materials and other materials listed in Subsection C, the rules of UG-20(f) may be applied to the portion constructed of P-No. 1 Group No. 1 or 2.

3.5.2 Interpretation VIII-1-95-15

The allowable temperature reduction determined from Fig. UCS-66.1 (coincident stress ratio less than 1) and the temperature reduction permitted by UCS-68(c) (postweld heat treatment when not otherwise a requirement) may be combined.

3.5.3 Interpretation VIII-1-95-160

The additional temperature reduction provided by UCS-68(c) may be applied to the provision of UCS-66(c), which allows ANSI B16.5 and B16.47 flanges and split loose flanges as specified within the Code paragraph, exemption from impact testing when the MDMT is no colder than -20°F .

3.5.4 UG-20(f) + UCS-66(b)

A temperature reduction determined from Fig. UCS-66.1 (coincident stress ratio less than 1) **may not** be applied in addition to an exemption from impact testing under UG-20(f).

3.5.5 UG-20(f) + UCS-68(c)

A temperature reduction permitted by UCS-68(c) **may not** be applied in addition to an exemption from impact testing under UG-20(f).

3.5.6 UCS-56 Note (2)(b) + UCS-68(c)

A temperature reduction permitted by UCS-68(c) **may not** be applied when the provisions of table UCS-56 Note (2)(b) are used to avoid the requirement to postweld heat treat (200 °F preheat for P-No. 1 materials over 1¼ in. nominal thickness through 1½ in. nominal thickness).

5.0 WELDING PROCEDURES

5.1 QW-407.2

This Supplementary Essential Variable requires that the procedure qualification test be subjected to PWHT essentially equivalent to that encountered in the fabrication of production welds, including **at least 80%** of the aggregate time(s) at temperature(s). For example, to remain within the WPS requirements, the maximum post weld heat treatment time(s) at temperature(s) for the production weld or production test coupons is 1.25 times the time(s) at temperature(s) qualified by the PQR coupon.

5.2 QW-403.6

This Supplementary Essential Variable specifies that the minimum base metal thickness qualified is the thickness of the test coupon T or ε inch, whichever is less. However where T is less than ¼ inch, the minimum thickness qualified is ½T.

5.3 UG-84(h)(2)(c) and UG-84(g)(5)

Paragraph UG-84(h)(2)(c) requires that the base material for the weld test coupon meet the minimum notch toughness requirement for the thickest material of the range of base material to be qualified by the procedure. Paragraph UG-84(g)(5) then requires that the weld metal impact test values match those for the base material. This paragraph may place an additional limit on the qualification thickness of a WPS, for instance when QW-403.7 allows the WPS to qualify to 8 inches. For example, assume a WPS is qualified on a P-No. 1 Group No. 1 base material which has a minimum specified yield strength of 55 ksi. If the test is made on a 1½ inch thick plate and the provisions of QW-403.7 are utilized, the test specimen would normally qualify the WPS for thicknesses up to 8 inches. Fig. UG-84.1 requires that the impact test results must average 30 ft-lbs. or more to qualify for a thickness of 3 inches or more.

6.0 FABRICATION

6.1 UCS-67(d)(2)

This paragraph stipulates that production impact testing of weld metal may be waived for the weld metals defined by paragraphs UCS-67(a)(2) and UCS-67(a)(3). It is our understanding that:

UCS-67(a)(2) defined weld metal is that applied in joining base metals exempt from impact testing by UCS-66(g) or Fig. UCS-66 curve C or D, for MDMTs colder than -20°F but not colder than -55°F , when welding consumables which have been classified by impact tests at a temperature not warmer than the MDMT by the applicable SFA specification are used.

UCS-67(a)(3) defined weld metal is that applied in joining base metals exempt from impact testing by UCS-66(g), for MDMTs colder than -55°F . It is ABSA's position that this exemption would also only be applicable when welding consumables which have been classified by impact tests at a temperature not warmer than the MDMT by the applicable SFA specification are used.

A more detailed explanation of this paragraph is not possible at this time, as there are no Code interpretations pertaining to the application of this paragraph that might further clarify the intent.

6.2 UCS-67(d)(3)

This paragraph stipulates that production impact testing of heat affected zones may be waived in steels exempted from impact testing by UCS-66 [any material above the UCS-66 curves or exempted from impact testing by UCS-66(g)], except when UCS-67(c)(3) applies [material exempted from impact testing by UCS-66(g) at MDMTs colder than -55°F].

6.3 UG-84(i)(1) General (Production Impact Test Plates)

The vessel impact test plate shall be from one of the heats of steel used for the vessel or group of vessels.

For Category A joints, the test plate shall, where practicable, be welded as an extension to the end of a production joint so that the test plate weldment will represent as nearly as practicable the quality and type of welding in the vessel joint. For example, a run-off tab would not be practicable for the Category A joint in a sphere made from 2 hemispheres.

For Category B joints that are welded using a different welding procedure than used on Category A joints, a test plate shall be welded under the production welding conditions used for the vessel, using the same type of equipment and at the same location and using the same procedure(s) as used for the joint, and it shall be welded concurrently with the production welds or as close to the start of production welding as practicable.

Under some circumstances when the above requirements have not been met, a test plate removed from the production weld seam has been accepted as meeting the Code provisions, but a production impact test plate cannot be welded after the fact.

6.4 UG-84(i)(3)(a) Number of Vessel Impact Test Plates Required

For each vessel, one test plate shall be made for each welding procedure used for joints of Categories A and B, unless the “vessel” is one of several as defined in UG-84(i)(3)(b) or (c).

A significant problem complying with this paragraph can be created when the possibility of repairs has not been considered before vessel fabrication. To illustrate the problem, consider a 4-inch thick vessel welded primarily with the SAW process. If a ½ thickness SMAW repair is required will the repair weld be qualified under the same WPS as was used for production welding and production impact test plates (does the WPS have adequate SMAW deposited weld metal thickness)?

6.5 UG-84(i)(3)(b)

For several vessels or parts of vessels, welded within any 3 month period at one location, the plate thickness of which does not vary by more than ¼ inch or 25%, whichever is greater, and of the same specification and grade of material, a test plate shall be made for each 400 ft of joints welded by the same procedure.

If it is intended to invoke the provisions of this paragraph, accurate records of Category A and B welding footage must be maintained by the manufacturer. The records must be acceptable to the A.I.

When reviewing the applicability of production impact tests that have been performed, against the requirements of UG-84(i)(3)(b), use the thickness of the test plate for determination of the 25% thickness variation provision not the thickness of the thickest part welded.

Questions have arisen as to the applicability of the limitations of UG-84(i)(3)(b) when a vessel has had impact test plates prepared in accordance with UG-84(i)(3)(a). For example what if the production welding extends beyond a three month time period. The time, thickness and footage limitations do not apply to production impact tests performed in accordance with UG-84(i)(3)(a).

6.6 ²UG-84(f)(2) Impact Testing of Welds

All test plates (**PQR and Production, when not exempted**) shall be subjected to heat treatment, including cooling rates and aggregate time(s) at temperature(s) as established by the Manufacturer for use in actual manufacture.

This paragraph can have significant consequences when an exemption under the referenced paragraphs is not available, for instance for P-No. 3, Gr. Numbers 1 and 2 materials. Reheat treatment of the vessel could lead to unacceptable WPS and production impact tests. **Material impact test results may also be unacceptable** under reheat treatment as provided for in Subsection C. Particular attention should be paid to this paragraph when dealing with UHT materials.

One must remember that irrespective of the Subsection C exemptions to UG-84(f)(2), the WPS(s) may become unacceptable if the vessel itself, or production impact test coupons are subjected to heat treatments that are outside of QW-407.2 requirements for the welding procedure [at least 80% of aggregate time(s) at temperature(s)].

7.0 TESTING

7.1 UG-84(j) Rejection

If the vessel test plate fails to meet the impact requirements, the welds represented by the plate shall be unacceptable. Reheat treatment and retesting or retesting only are permitted.

Under the provision for reheat treatment it is necessary to consider the applicability of the welding procedure under QW-407.2, as well as UG-84(f)(2) implications.

² Please note: There appears to be an error in the Code reference to paragraph UCS-85(f) within paragraph UG-84(f)(2). In the A92 addenda UCS-85(f) became UCS-85(g). Paragraph UCS-85(g) is where the reference to P-No. 3, Gr. Nos. 1 and 2 materials is located in the A99 addenda.