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Teaching how to determine the Charpy impact according to the general requirements defined in part-UG of the ASME VIII code division 1

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ABSTRACT: The objective of the present work is to teach the criteria proposed by the ASME VIII code division 1 to determine when an impact test should be carried out on a base metal and on a welded joint using the general requirements specified in general requirements, which is defined in part UG,of the ASME VIII code div. 1. Charpy impact the can be used to evaluate the toughness of metallic materials that are listed in ASME II and Article QW-422 ASME IX. This paper presents a methodology through flow diagrams that allows the student to determine in a simple way when and how to carry out the Charpy test on a welded joint or a base metal. This methodology was applied to students of the Technical University of Madrid in the last years of university. Future work will explain how to determine the Charpy impact for the [UCS, UHT and UHA] parts of ASME VIII div. 1.

KEYWORDS: ASME VIII; Charpy; Resilience; Toughness; Welding

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RESUMEN: *Enseñar a cómo determinar el impacto de Charpy de acuerdo con los requisitos generales definidos en la parte UG del código ASME VIII división 1*. El objetivo del presente trabajo es enseñar los criterios propuestos por el código ASME VIII división 1 para determinar cuándo se debe realizar una prueba de impacto en un metal base y en una unión soldada utilizando los requisitos generales especificados en los requisitos generales, que se definen en parte UG, del código div ASME VIII. 1. El impacto Charpy se puede utilizar para evaluar la tenacidad de los materiales metálicos que se enumeran en ASME II y en el Artículo QW-422 de ASME IX. Este documento presenta una metodología a través de diagramas de flujo que le permite al estudiante determinar de manera simple cuándo y cómo realizar la prueba de Charpy en una unión soldada o un metal base. Esta metodología se aplicó a estudiantes de la Universidad Politécnica de Madrid en los últimos años de universidad. El trabajo futuro explicará cómo determinar el impacto de Charpy para las partes [UCS, UHT y UHA] de ASME VIII div. 1.

PALABRAS CLAVE: ASME VIII; Charpy Resistencia; Soldadura; Tenacidad

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1. INTRODUCTION

Towards the end of the 19th century and the beginning of the 20th, a series of catastrophic boiler failures in the United States led to the first actions aimed at establishing rules for the design and construction of boilers. At that time, there were 350 to 400 boiler explosions per year, in the US alone, with many losses of human life and serious damage to the facilities and plants in which they operated. As a result, the American Society of Mechanical Engineers (ASME) issued its first code in 1914. Fig. 1 shows the structure of the ASME VIII code div. 1.

The parts used in the ASME VIII code div. 1 to determine the Charpy impact are Section A: Part UG; Section B: Part UW and Section C: Parts UCS, UHT and UHA.

It is of great importance that final year students of mechanical engineering degrees have an academic background that deals with the reference design codes used nowadays because these engineers will find them very useful for their professional performance.

There are publications in the field of technical training that cover the ASME IX (Meseguer-Valdenebro *et al.*, 2017) code, the influence of alloy elements on the properties of materials (Meseguer-Valdenebro *et al.*, 2015) and on other engineering issues related to metallurgy and welding (Dugan and Chang, 2010; Bose, 2011; Javier Naranjo and Alejandro Torres, 2015; Meseguer-Valdenebro *et al.*, 2016; Romaní *et al.*, 2017), but there is no academic work in the field of technical training explaining how to determine the Charpy impact according to the ASME VIII code div. 1.

1.1. Background of the Charpy test

The Charpy pendulum is a pendulum designed by Georges Charpy that is used in tests to determine the tenacity of a material. They are impact tests of a test specimen fitted and tested to flex in 3 points. The pendulum hits the back of the test tube and breaks it. The difference between the initial height of the pendulum (h) and the final height after the impact (h') allows measuring the energy absorbed in the process of fracturing the specimen. Strictly speaking, the energy absorbed in the area under the load curve is measured, which is known as resilience

The energy absorbed in the impact by the specimen is usually calculated as the difference of the initial and final pendulum heights, this implies, obviously, neglecting some friction losses. The calculation formula for the impact energy is Eq. (1):

$$T = P(h - h')g = Pl(\cos\beta - \cos\alpha)g \tag{1}$$

where:

T, is the energy used in the break in Joules, P is the mass of the pendulum in kg, g is gravity (9.80665 m·s²), h is the initial height of the

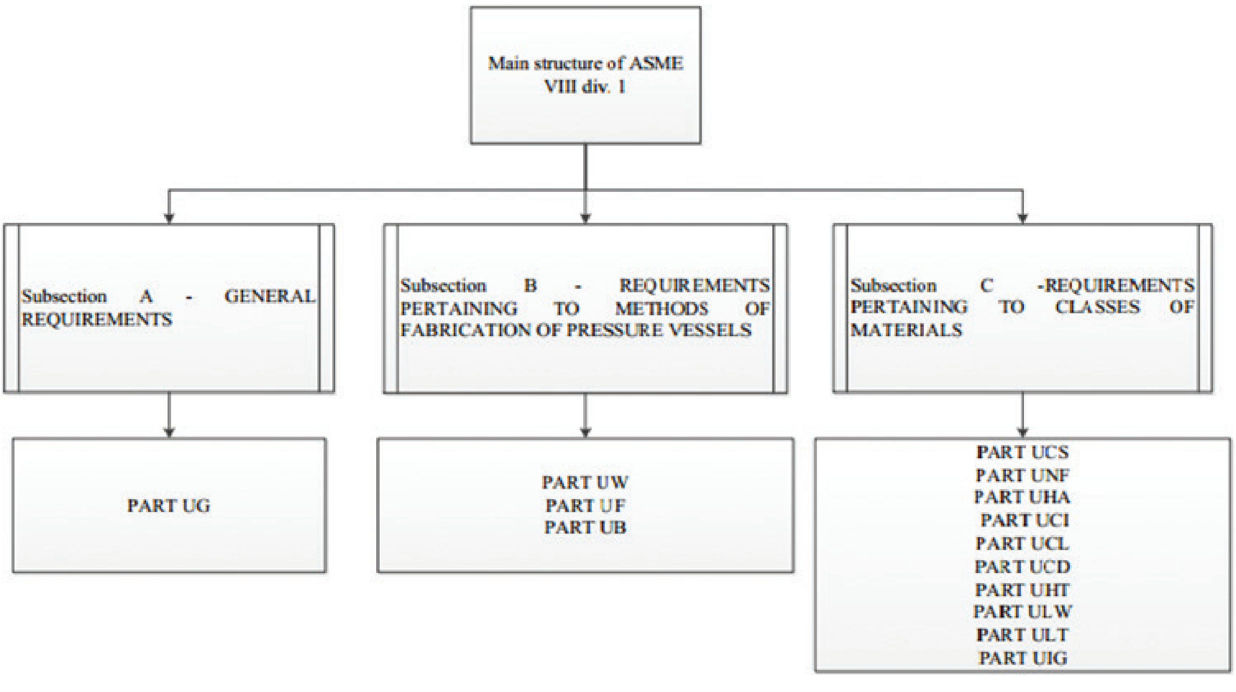

Figure 1. Structure of the ASME VIII div. 1 code.

pendulum, *h'* is the final height of the pendulum, *l* is the length of the pendulum in meters, α and β are the angles that form the pendulum with the vertical before and after releasing it, respectively.

Figure 3 shows the Charpy impact specimen placed on the Charpy pendulum before being broken by the pendulum (Fig. 2).

Toughness in steels is controlled by different microstructural constituents. Some of them, like inclusions, are intrinsic while others happening at different microstructural scales relate to processing conditions (Gutiérrez, 2014).

Figure 4 (Gliha *et al.*, 2004) shows schematically the changes of microstructure that occur in a multiple-pass weld. The zone affected by heat, whose microstructure is thickened by the first cycle, changes to different microstructures according to the thermal sequence of the subsequent passes. When the maximum temperature of the second pass is immediately above the upper critical line (AC3), the microstructure is refined, which is usually called the normalized effect (C in Fig. 3); when the temperature is less than AC1, the microstructure is only relieved (A in Fig. 3). In the event that the reheat temperature is between AC3 and AC1 (called the inter-critical zone of temperatures), local regions enriched in carbon are generated with the risk of forming fragile microstructures (B in Fig. 3). This dual-phase region also exists approximately 3 mm from the fusion line of the first pass. Through the simulation of thermal welding cycles it was determined that, from the point of view of microstructures, the greatest deterioration in the toughness of the HAZ is due to the formation of local fragile zones (LBZ) (other factors are grain growth) and presence of impurities), the authors (Yurioka, 1995; Zalazar *et al.*, 2000) agree in establishing that they originate in a multiple-pass weld, mainly in the region identified as a coarse-grained zone overheated in the intercritical region of temperatures. The LBZ are strongly affected by metallurgical factors such as the martensite islands, so their presence is influenced by the chemical composition of the alloy and by the succession of thermal cycles to which the base metal is subjected. Some authors report equations that link the influence of LBZ on the transition temperature; others, however, consider that the deterioration of the mechanical properties due to the LBZ does not depend on the percentage thereof. The morphological aspect of the LBZ, which may have an elongated shape, should also be considered in the analysis when the length / width ratio of the phase is 4/1. At this point there is a discrepancy as to its influence on the mechanical properties. In steels with nickel, molybdenum and higher percentages of carbon, both types of LBZ are formed, and together with the matrix they deteriorate the tenacity of the base metal. The cooling time, from the second welding cycle, between 800 °C and 500 °C ($t_{8/5}$) influences not only the appearance of these phases, but also the morphology they present (Zalazar *et al.*, 1998).

FIGURE 2. Photo of the Charpy pendulum used to teach students.

FIGURE 3. Sample used to test using Charpy impact.

2. SECTION A OF THE ASME VIII CODE, DIV. 1

Section A of the ASME VIII code div. 1 that determines the Charpy impact describes the general requirements (UG) and the points UG-20 and UG-84.

2.1. UG-20: Design temperature

The design temperature is the temperature at which the pressure equipment is designed. The design temperature will determine the energy required for the Charpy impact that will be carried out according to the operating temperature of the pressure vessel. The structure of paragraph UG-20 is shown in Fig. 5.

Paragraph UG-20 is then broken down to explain each of its parts.

Maximum temperature used in design: The maximum temperature defined in the design will not be less than the average temperature under operating conditions; it is considered the average temperature of the metal (through the thickness). If the pressure vessel is directly subjected to the flame, then point UW-2 section d) -3 will be applied, which indicates that the welded joints under pressure, thus the affected joints will be designed at temperatures not

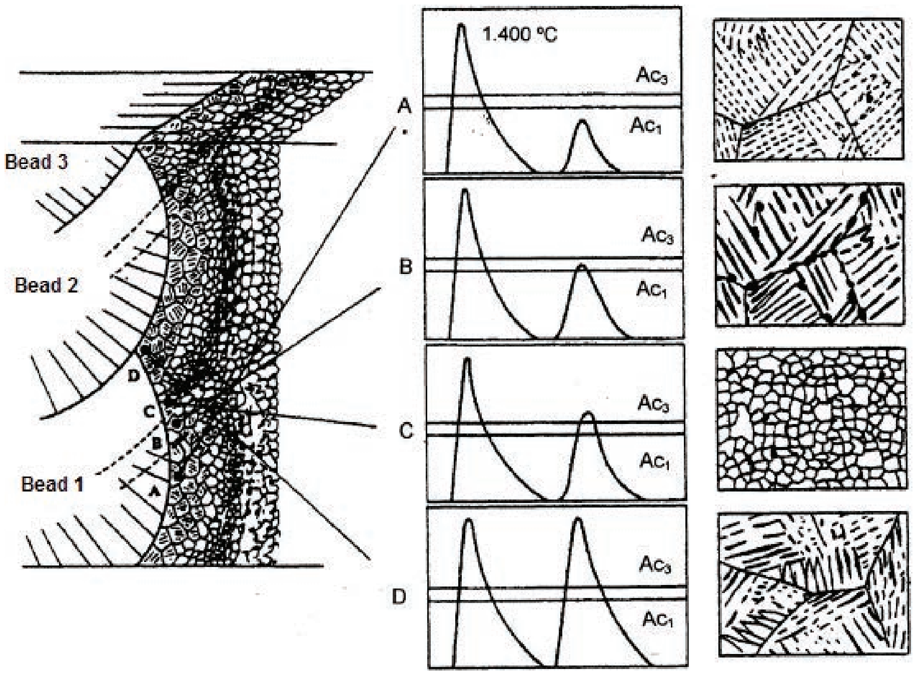

Figure 4. Schematic diagram showing the relation between microstructure and thermal cycle in the HAZ.

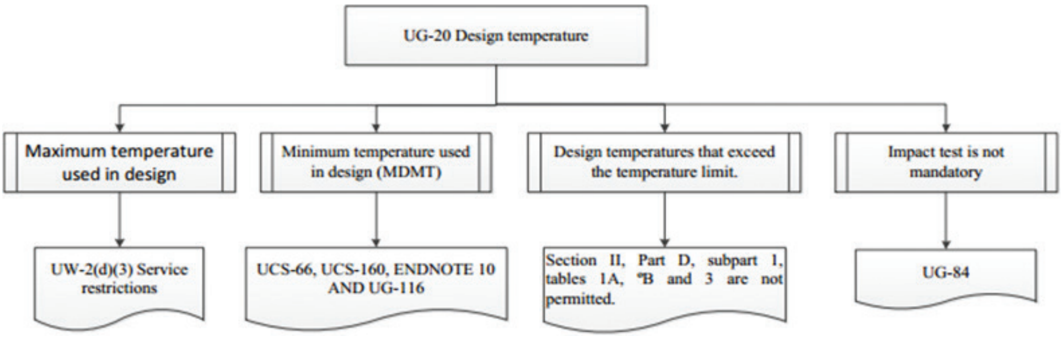

Figure 5. Structure of paragraph UG-20.

lower than the maximum metal temperature on its surface under operating conditions. The maximum temperatures will be determined by calculations or by direct measurement on the pressure vessel in service.

Minimum design temperature: The minimum design temperature is also known as MDMT. The minimum operating temperature is the minimum temperature in service. The MDMT will be determined either numerically or experimentally and will be registered in the registration tag of the pressure vessel together with the maximum admissible working pressure, also known as MAWP. If lower temperatures are allowed by paragraphs UCS-66 and UCS-160 then the MDMT temperature will be in accordance with these paragraphs. These paragraphs will be discussed later.

Impact test: The impact test according to UG-84 is not mandatory for materials subjected to pressure that meet the following conditions:

– The material will be P-Nº1, Gr. Nº 1 or 2 and the thickness will be defined in UCS-66 (a) and the thickness will not exceed 13 mm for the materials of curve A and 25 mm for curve B, C or D according to UCS-66. These curves are not the subject of this work. These curves will be mentioned when the work on the impact test for low alloy steels and carbon steels is published.
– Once the hydrostatic pressure test has been carried out according to UG-99.
– The design temperature will be between 345 ºC and -29 ºC. Temperatures below -29 ºC will be acceptable if the ambient temperature requires it.

– Shock loads of thermal origin as mechanical are not a design requirement.
– Cyclical loads are not a design requirement.

2.2. UG-84: Charpy impact test

In paragraph UG-84 all the points that affect the Charpy test are developed according to the general design rules.

The structure of paragraph UG-84 is schematized in Fig. 6.

(a) **General:** The V-notch for the Charpy test will be made on all those materials that are subject to the service voltage of the pressure vessel and the impact tests performed will be in accordance with subsection C of this code.
(b) **Test procedures:** The pressure vessels used to carry out the tests shall comply with SA-370 or ISO 148 (parts 1, 2 and 3). Unless permitted by the UG-84.4 table, the test temperature shall not be hotter than the minimum of the design metal conforming to UG-20 (minimum design temperature). The temperature of the test may be colder than the minimum specified in the material specification in Section II.
(c) **Test specimens: (c.1)** each set of tests will consist of three specimens. **(c.2)** The specimen of the impact test will be with a V-shaped preparation and will be according to Fig.7. The standard specimen will be 10 mm x 10 mm, when it can be obtained, and it will be used on a nominal thickness of 11 mm or more. For example, if the thickness of the sheet to be tested is 20 mm, it will be machined to a thickness of 10 mm. **(c.3)** For materials that are capable of absorbing energy above 240 J, a specimen of 10 mm x 6.7 mm can be used and the minimum value required to accept the test is 100 J and the minimum lateral expansion will be recorded in mm. **(c.4)** When 10 mm x 10 mm specimens cannot be extracted either due to the thickness or the geometry of the sheet to be tested, the specimens will be as long as possible or a specimen will be extracted from the thickness of the material that is formed by the pressure vessel. The specimen can be machined to eliminate surface irregularities. For example, if the height of a specimen is 9 mm, the length of the specimen should be 55 mm plus a length equivalent to 5.5 mm for having lost a thickness of 1 mm, thus maintaining the volume of material tested. **(c.4.1)** If the thickness of the specimen tested is less than 10 mm, the materials used are contained in table UCS-23 (MEGA, 2017) and the tensile stress is less than 655 MPa, so the width of the specimen along the notch will be less than 80% of the nominal thickness of the material and the test temperature shall not be higher than the MDMT temperature. For example, if we have

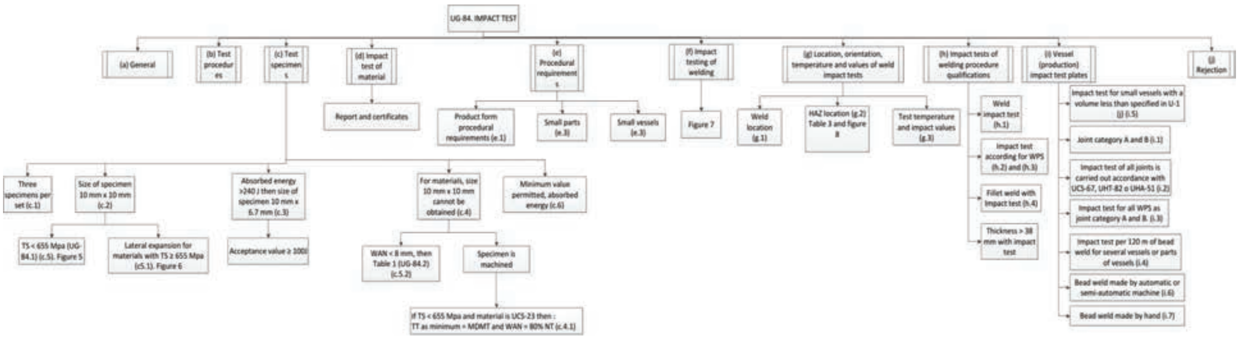

FIGURE 6. Structure of paragraph UG-84.

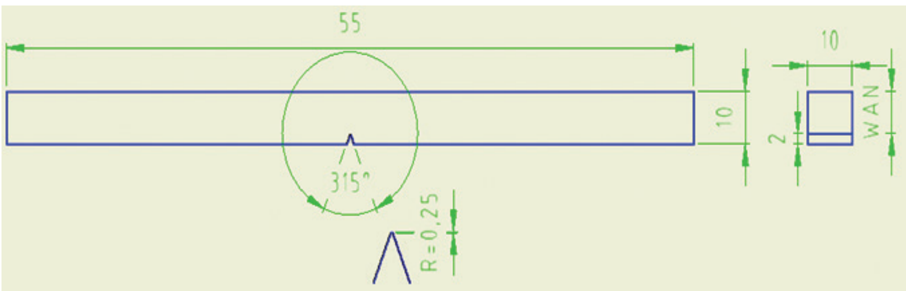

FIGURE 7. Charpy impact test specimen.

an SA-36 steel, it is registered in the UCS-23 table and has a tensile stress below 655 MPa, its Charpy test temperature will not be warmer than its MDMT. The Charpy test will not be performed for those specimens that have a WAN of less than 2.5 mm.

(c.5) To determine the impact energy that a material must absorb, whether base material or welding, with a tensile strength of less than 655 MPa, the nominal thickness of the material must be entered on the abscissa axis and the ordinate on the ordinate obtains the average energy from the three tests performed multiplied by the quotient between the WAN and the total width of the specimen (10 mm, for a standard specimen) (Fig. 8) and the result is the minimum elastic limit of the material. For example, if we have a housing of a pressure vessel of 30 mm thickness and a tensile strength lower than 655 MPa and we want to test it on impact, 3 test pieces of the same material are machined according to Fig. 7, that is, 10 mm x 10 mm and each of the test pieces is tested separately at a temperature no hotter than its MDMT, giving an average value of 25 J multiplied by 0.8, obtaining 20 J; it is therefore determined that the material has an elastic limit of 260 MPa.

(c5.1) The minimum lateral expansion on the opposite side of the notch for all specimen sizes according to table UCS-23 and having a tensile strength greater than or equal to 655 MPa will require Fig. 9, corresponding to UHT- 6.1 of the ASME VIII code div. 1. For UHT materials, the UHT-6 (a) (3) and UHT-6 (a) (4) requirements will apply. For the UHA-23 material table all UHA-51 requirements will apply. The UHA and UHT materials are not the object of this article, therefore this last line is merely informative.

(C.5.2) For nominal thicknesses greater than or equal to 10 mm, the WAN will be equal to 8 mm and the test temperature will not be hotter than the MDMT. If the WAN is less than 8 mm the test will be performed at a lower temperature

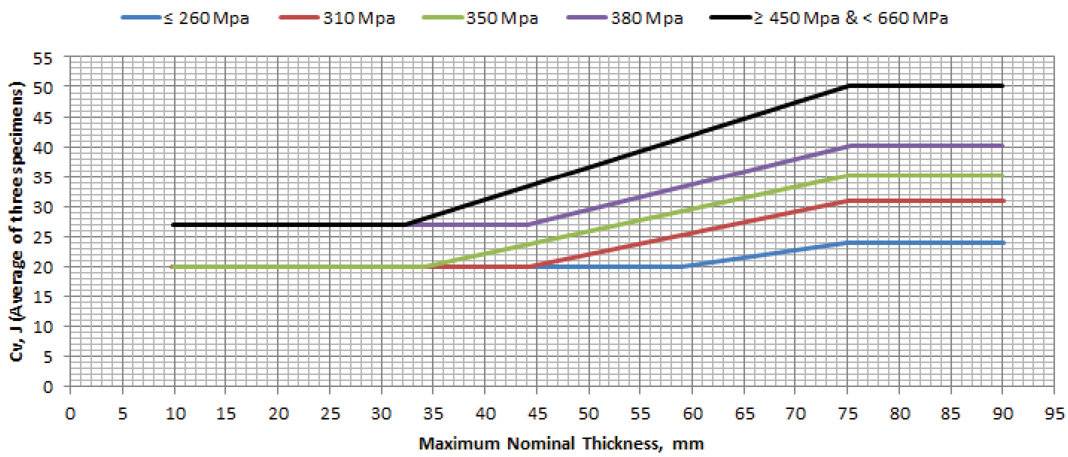

FIGURE 8. UG-84.1. Charpy impact test requirements for carbon steel and low alloy steel samples (listed in UCS-23) having a tensile stress lower than 655 MPa.

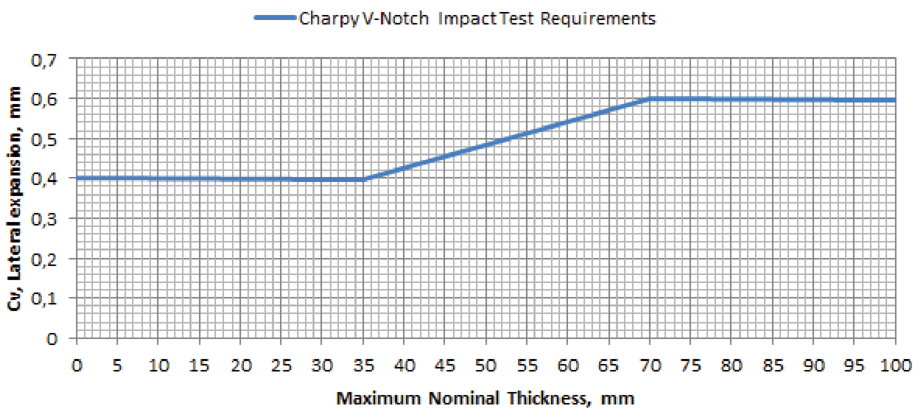

FIGURE 9. Lateral impact requirements for materials that have a tensile strength equal to or greater than 655 MPa.

TABLE 1. Charpy impact test temperature reduction below MDMT, Table UG-84.2

Thickness (mm)	Temperature reduction (ºC)
10	0
9	0
8	0
7,5	3
7	4
6,7	6
6	8
5	11
4	17
3,3	19
3	22
2,5	28

General note: For table UCS-23 materials having a specified minimum TS of less than 655 MPa when the sub-size Charpy impact is WAN < 80% NT

TABLE 2. Specifications for impact tested materials in various product forms (Table UG-84.3)

Product form	Specification
Plates	
Parts UCS and UHT	SA-20, S5
Part UHA	SA-480
Pipe	SA-333
Tubes	SA-334
Forgings	SA-350
Castings	SA-352
Bolting materials (and bars)	SA-320
Piping fittings	SA-420

than the MDMT according to that indicated in Table 1.

(c5.3) For nominal material thicknesses less than 10 mm. If the WAN is at least 80% of the nominal thickness, the Charpy test will be carried out at a temperature no hotter than the MDMT.

(c.6) When the average value of three specimens equals or exceeds the minimum value allowed for a single specimen and the value for more than one specimen is less than the average value required or when the value for a specimen is less than the minimum allowed value, a new specimen will be made with a trial of three additional specimens. The value of each of the three specimens will equal or exceed the average value required.

(d) **Material impact tests: (d.1)** The impact tests carried out will be certified by the manufacturer of the material, and will indicate that the specimens comply with UCS-85, UHT-5 or UHT-81, as applicable. **(d.2)** The manufacturer of the pressure vessel can perform impact tests to check the validity of the material when impact tests do not appear in the quality certificates of the manufacturer of the material.

(e) **Procedural requirements: (e.1)** when the procedural requirements of the product form are not registered in the specifications of the material, the impact test will be carried out on the procedural requirements of the product forms indicated in Table 2.

(e.2) The manufacturer of small components, either wrought iron or foundry, can certify a batch formed by a maximum of 20 pieces; each batch will be from the same casting, heat treatment and production process. A piece will be randomly selected and a set of three specimens will be extracted to test impact. If the piece is so small that 3 specimens of the size indicated in figure 4 cannot be extracted, it will not be necessary to perform the Charpy test.

(e.3) The manufacturer of small pressure vessels only requires a set of three impacts of a maximum batch of 100 pressure vessels of the same cast or a batch of pressure equipment that carries the same heat treatment, the smallest will be chosen from among the 100 pressure vessels and a batch of thermally treated pressure vessels.

(f) **Welding impact test: (f.1)** For welded steel pressure vessels, the impact test of the weld and the heat affected zone (HAZ) of the sheet and pressure equipment qualification procedure. **(f.2)** all sheets that are subject to heat treatment, including cooling rates and the agreed time to temperature or temperatures set by manufacturer. The thermal requirements of UG-85, UCS-85, UHT-81 and UHT-82 will apply to sheet tests except if the UCS-85 (f) and UCS-85 (g) points are not applicable. This last paragraph is developed in Fig. 10.

(g) **Location, orientation, temperature and values of the impact test in the welding. (g.1)** For each set of weld metal specimens to be impact tested, the notch area must be removed through the weld, each specimen will have the normal notch to the weld surface and one face of the specimen to be impact tested will be 1.5 mm from the surface of the material. **(g.2)** each set of test pieces to test the impact, extracted from the HAZ through the welding metal, the notch of the specimen will be in the HAZ zone. The numbers of sets of impact specimens are shown in Fig. 11 and Table 3. The notch will be cut approximately normal to the surface of the material so that it contains as much HAZ as possible in the fracture test. **(g.3)** the test temperature for welding

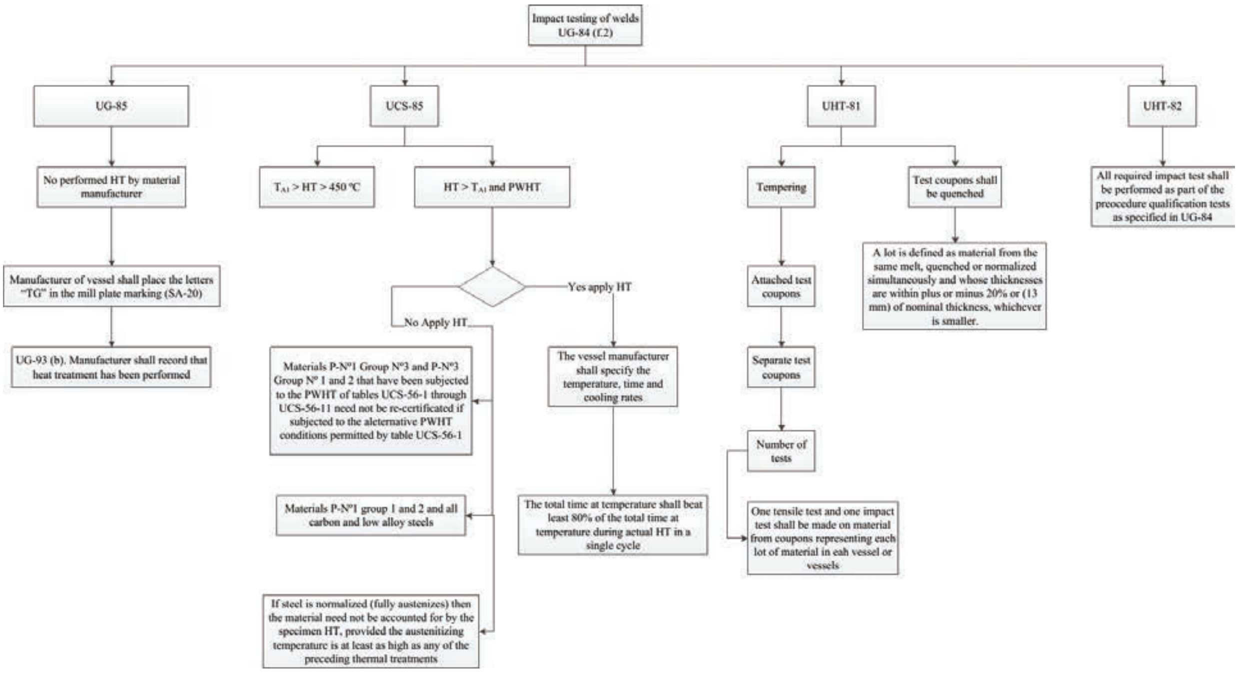

FIGURE 10. Impact testing of welds UG-84 (f.2).

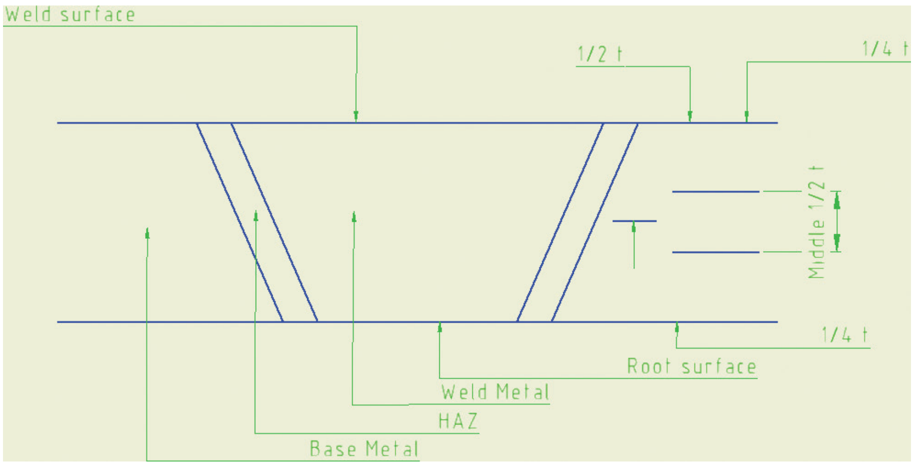

FIGURE 11. HAZ Impact Specimen Removal. UG-84.5.

and HAZ will not be higher than that required in the base metal. The impact values will be at least as high as the impact values of the base metal.

For example, if you must perform two sets of tests, according to Table 3, because you have a weld with a thickness of 40 mm and a preparation of edges in X, then it must be extracted on two sides (see note 2 of table 3), and so 6 specimens should be tested using the Charpy pendulum.

(h) **Welding procedure qualification impact test. (h.1)** The impact test of the weld bead and of the HAZ will be carried out according to point (g) described above. **(h.2)** The impact tests according to the welding procedure will be carried out in accordance with UCS-67, UHT-82 or UHA-51 depending on the material used in the welding process. When the base metal sheet is in accordance with the part of the UCS code, the following conditions must be met: (1) The base material must have the same P-N and Group; (2) Have the same heat treatment; and (3) Meet the minimum strength requirements in the notch described in (c.5) and (c.5.1). **(h.3)** If the impact test is required for the weld metal, but is not required for the base metal (because the base metal conforms to UHA-51) the welding

Table 3. Impact test specimens of the HAZ, UG-84.6

Removal depth and number of specimen sets				
Base metal thickness (t)	**Single-sided weld**	**Nº sets**	**Two-sided weld**	**Nº sets**
t ≤ 19 mm	1/4t to 1/2t	1	Middle 1/2t	1
19 mm < t < 38 mm	1/4t to 1/2t	1	1/4t to 1/2t	2
t ≥ 38 mm	1/4t to 1/2t	2	1/4t to 1/2t	2

GENERAL NOTE: Testing shall be performed on sets of three impact test specimens as required by UG-84(c) (1). Each specimen must be full size, or the largest sub-size specimen that may be removed from the available material thickness as required by UG-84(c) (2). The specimen sets shall be removed at the indicated depth from the weld surface and prepared as specified in UG-84(g) (2).
NOTES:
(1) For two-sided welds in base metal thicknesses of 19 mm or less, a single specimen set removed from the middle ½ t shall represent the HAZ of the welds applied to both surfaces.
(2) For two-sided welds in base metal thicknesses greater than 19 mm, specimen sets shall be removed from a depth of between ¼ t and ½ t from each weld surface.
(3) For single-sided welds in base metal thicknesses of 38 mm or greater, one specimen set shall be removed from a depth of between ¼ t and ½ t from the weld surface, and a second specimen set shall be removed from a depth of between ¼ t and ½ t from the root surface.

procedure will involve a set of impact tests on the weld metal with the notch perpendicular to the surface, but the impact test on the HAZ will not be performed. **(h.4)** If the welding process used in production is used in fillet welds, the welding process must be qualified by a butt joint of two sheets or tubes and must meet the requirements (1), (2) and (3) the point (h.2). If a P-N 11 is welded, the requirements that apply to paragraph QW-202.2 of ASME IX apply. **(h.5)** when testing sheets thicker than 38 mm, three sets of impacts will be required. One set of impacts will be extracted from the HAZ as shown in (g.2) and the remaining two sets will be extracted from the weld, where one of the sets will be drawn to 1.5 mm from the surface as shown in (g.1) and the second set will be drawn between the surface and the center of the thickness. (**h.6)** The supplementary variables according to ASME IX become essential variables if the impact test is applied.

(i) **Impact test plates for pressure vessels (production) (i.1)** Considering the requirements established in points h and g for welding procedures, the impact tests will be carried out for the same type of casting used for the same type or group of pressure vessels. For category A and category B joints, the Charpy test will be carried out on a weld bead representative of the quality of the joint. The welding procedures used for Category A and B seals must be different and the same welding machines must be used as those used in production. The categories A and B of the welded joints are defined in the ASME VIII code div. 1 UW-3 **(i.2)** the impact test will be carried out for all joints when the impact test is required in the welding procedure according to UCS-67, UHT-82 or UHA-51. The impact test will be carried out in the bead weld and HAZ. **(i.3)** For each pressure vessel, a test on the sheet will be done for each WPS of the joints with categories A and B. **(i.4)** If there is a batch of pressure vessels of the same cast or parts of pressure vessels welded in a period of 3 months in one location, the thickness of the sheet will not vary by more than 6 mm or more than 25%, whichever is greater, and an impact test will be performed every 120 m of welding for welded joints that have used the same WPS. **(i.5)** For a batch of a maximum of 100 small pressure vessels that do not exceed the volume defined in form U-1 (j) of the same pour, a weld impact test performed for a WPS with the same filler material represents the batch of 100 small pressure vessels. **(i.6)** If a welding is done with an automatic or semi-automatic machine, an impact test will be carried out for each welding position. **(i.7)** If a manual weld is made, an impact test will be performed for the flat position only, but if the welding is done in other positions, the impact test will be performed only in the vertical position. The vertical position qualifies the rest of the welding positions.

(j) **Rejection.** If the tested plates fail in the impact requirements, the welds will not be acceptable. A new heat treatment and a new test or only a new test will be allowed to accept the material as suitable.

3. STUDENT FEEDBACK

This course was taught to two groups, A and B, with 29 and 33 students, respectively. The knowledge of both groups was assessed upon performing an impact test according to the general requirements as per the ASME VIII div. 1 part UG code. To check the effectiveness of the learning procedure, the tables and figures explaining the ASME VIII div. 1 part. UG code provided in this work were only introduced to group A, while the ASME VIII div. 1 part. UG code was presented directly to group B, without these figures and tables. To be pragmatic, we will call them the test sample and the control sample, respectively. Once the antecedents and the methodology were presented to the students, a short multiple-choice questionnaire was presented to both groups at the same time. In addition, once the results comparing groups A and B were obtained, the lecturer carried out a survey among group A to estimate group satisfaction with the new approach. In the questionnaires, the correct answers are measured over a given period of time. If the time established for the evaluation is exceeded, only those answers answered within the time established in the test will be evaluated. It has been proven that those students who answered the most correct questions were those who used the tables and diagrams presented in this article, however, those students who did the test directly using the code ASME VIII div. 1, in addition to answering fewer questions, they made more mistakes. As an example, Fig. 6 relates the MDMT to UW-2 (d) (3), the question that addressed this question was not answered or answered erroneously by those students who used the ASME VIII code, div. 1.

The main advantage of these schemes is shown in Fig. 6, where the article UG-84 is structured in all the subsections that this article is formed. By means of a swipe of view you can see the structure and be able to choose the best option in front of a question formed in a test of evaluation type of ASME VIII div. 1.

Table 4 shows the results of the questionnaire for the test and the control groups. Although the total sample size is small, the comparison between groups suggests that the proposed method increases the comprehension level of the students related to their knowledge about the role of the alloy elements in steels, which can lead to a better understanding of this subject matter. Lecturers are continuing to gather more data for a more reliable statistical study for further conclusions in future works.

There are other works that have used other different teaching methodologies (Vergara and Rubio, 2012; López-Martínez *et al.,* 2014; Vergara *et al.*, 2016; Jurado-Navas and Munoz-Luna, 2017) from that used in the workplace but which have helped me to create this new method of teaching the complex but very useful ASME VIII code div. 1.

Table 4. Results from the questionnaire applied at the same time to group A (test sample) and group B (control sample)

Questionnaire	Test sample (A)	Control sample (B)
Sample size	29	33
Success ratio (%)	92	84
Standard deviation	6.1	5.2

4. CONCLUSIONS

– The use of schemes helps students to understand how to carry out a Charpy test as per the ASME VIII div. 1 part UG code presented here. This is a new methodology that is being used in the Technical University of Madrid, and has produced very satisfactory results for student careers, as the ASME VIII div. 1 part UG code is widely used in industry.
– The schemes are flowcharts that summarize the ASME VIII div. 1 part UG code to help students to determine how to define the parameters of an impact test according to the general requirements from ASME VIII div. 1 and determine if supplementary variables of WPS/WPQR are essential variables.

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Nomenclature (Abreviations)

HAZ	Heat Affected Zone
HT	Heat treatment
LBZ	Local Fragile Zones
MDMT	Minimum design temperature
MAWP	Maximum admissible working temperature
NT	Nominal thickness
P-N	P Number
PWHT	Post-weld heat treatment
SA-20	ASTM S-20. Standard specification for general requirements for steel plates for pressure vessels
T_{A1}	Low transformation temperature
TS	Tensile strength
TT	Temperature test
Part- UB	Requirements for pressure vessels fabricated by brazing
Part- UCD	Requirements for pressure vessels constructed of cast ductile iron
Part- UCI	Requirements for pressure vessels constructed of cast iron
Part- UCL	Requirements for welded pressure vessels constructed of materials with corrosion resistant integral cladding, weld metal overlay cladding or with applied linings
Part- UCS	Requirements for pressure vessels constructed of carbon and low alloy steel
Part- UF	Requirements for pressure vessels fabricated by forging
Part- UG	General requirements for all methods of construction and all materials
Part-UHA	Requirements for pressure vessels constructed of high alloy steel
Part-UHT	Requirements for pressure vessels constructed of ferritic steels with tensile properties enhanced by heat treatment
Part-UIG	Requirements for pressure vessels constructed of impregnated graphite
Part-ULT	Alternative rules for pressure vessels constructed of materials having higher allowance stresses at low temperature
Part-ULW	Requirements for pressure vessels fabricated by layered construction
Part-UNF	Requirements for pressure vessels constructed of non-ferrous materials
Part-UW	Requirements for pressure vessels fabricated by welding
WAN	Width along the notch
WPS	Welding Procedure Specification

Points treated in ASME VIII div 1 to determine the Charpy impact

U-1	Forms. Manufacturer's data report for pressure vessels
UCS-56.1	Alternative PWHT requirements for Carbon and Low Alloy Steels
Table UCS-56-1	Post-weld Heat Treatment Requirements for Carbon and Low Alloy Steels - P-No. 1
Table UCS-56-11	Post-weld Heat Treatment Requirements for Carbon and Low Alloy Steels - P-No. 15E
UCS-85	Heat treatment of test specimens
UG-84	Charpy Impact Test
UG-85	Heat treatment
UG-93	Inspection of materials
UHT-81	Heat treatment verification tests
UHT-82	Welding
UW-3	Welded joint category