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PART UB
REQUIREMENTS FOR PRESSURE VESSELS FABRICATED BY BRAZING

GENERAL

UB-1 SCOPE

(a) The rules in Part UB are applicable to pressure vessels and parts thereof that are fabricated by brazing and shall be used in conjunction with the general requirements in Subsection A, and with the specific requirements in Subsection C that pertain to the class of material used.

(b) Definition. The term brazing as used in Part UB is defined as a group of welding processes that produce coalescence of materials by heating them to the brazing temperature in the presence of a filler metal having liquidus above 840°F (449°C) and below the solidus of the base metal. The filler metal is distributed between the closely fitted surfaces of the joint by capillary attraction.

(c) Specific brazing processes which are permitted for use under this Division are classified by method of heating as follows:

(1) torch brazing;
(2) furnace brazing;
(3) induction brazing;
(4) electrical resistance brazing;
(5) dip brazing — salt and flux bath.

UB-2 ELEVATED TEMPERATURE

Operating temperature is dependent on the brazing filler metal as well as on the base metals being joined. The maximum allowable operating temperatures for the brazing filler metals are shown in Table UB-2.

UB-3 SERVICE RESTRICTIONS

Brazed vessels shall not be used for services as follows:

(a) lethal services as defined in UW-2(a);
(b) unfired steam boilers as defined in U-1(g);
(c) direct firing [see UW-2(d)].

MATERIALS

UB-5 GENERAL

(a) Materials used in the construction of pressure vessels and parts thereof by brazing shall conform to the specifications in Section II and shall be limited to those materials for which allowable stress values have been assigned in the tables referenced by UG-23.

(b) Combinations of dissimilar metals may be joined by brazing provided they meet the qualification requirements of Section IX, and the additional requirements of UB-12 when applicable.

UB-6 BRAZING FILLER METALS

The selection of the brazing filler metal for a specific application shall depend upon its suitability for the base metals being joined and the intended service. Satisfactory qualification of the brazing procedure under Section IX and when necessary based on design temperature, with the additional requirements of this Section, is considered proof of the suitability of the filler metal. Brazing with brazing filler metals other than those listed in Section II, Part C, SFA-5.8 shall be separately qualified for both procedure and performance qualification in accordance with Section IX and when necessary with the additional requirements of this Section.

UB-7 FLUXES AND ATMOSPHERES

Suitable fluxes or atmospheres or combinations of fluxes and atmospheres shall be used to prevent oxidation of the brazing filler metal and the surfaces to be joined. Satisfactory qualification of the brazing procedure under Section IX and when necessary based on

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TABLE UB-2
MAXIMUM DESIGN TEMPERATURES FOR BRAZING FILLER METAL

Filler Metal Classification	Column 1 Temperature, °F (°C), Below Which Section IX Tests Only Are Required	Column 2 Temperature, °F (°C), Range Requiring Section IX and Additional Tests
BCuP	300 (149)	300–350 (149–177)
BAg	400 (204)	400–500 (204–260)
BCuZn	400 (204)	400–500 (204–260)
BCu	400 (204)	400–650 (204–343)
BAlSi	300 (149)	300–350 (149–177)
BNi	1200 (649)	1200–1500 (649–815)
BAu	800 (427)	800–900 (427–482)
BMg	250 (121)	250–275 (121–135)

GENERAL NOTE: Temperatures based on AWS recommendations.

design temperature, with the additional requirements of this Section, is considered proof of the suitability of the flux and/or atmosphere.

DESIGN

UB-9 GENERAL

The rules in the following paragraphs apply specifically to pressure vessels and parts thereof that are fabricated by brazing and shall be used in conjunction with the general requirements for *Design* in Subsection A, and the specific requirements for *Design* in Subsection C that pertain to the class of material used.

UB-10 STRENGTH OF BRAZED JOINTS

It is the responsibility of the Manufacturer to determine from suitable tests or from experience that the specific brazing filler metal selected can produce a joint which will have adequate strength at design temperature. The strength of the brazed joint shall not be less than the strength of the base metal, or the weaker of two base metals in the case of dissimilar metal joints.

UB-11 QUALIFICATION OF BRAZED JOINTS FOR DESIGN TEMPERATURES UP TO THE MAXIMUM SHOWN IN COLUMN 1 OF TABLE UB-2

Satisfactory qualification of the brazing procedure in accordance with Part QB of Section IX is considered evidence of the adequacy of the base materials, the brazing filler metal, the flux and/or atmosphere, and other variables of the procedure.

UB-12 QUALIFICATION OF BRAZED JOINTS FOR DESIGN TEMPERATURES IN THE RANGE SHOWN IN COLUMN 2 OF TABLE UB-2

For design temperatures in the range shown in Column 2 of Table UB-2, tests in addition to those in UB-11 are required. These tests shall be considered a part of the qualification procedure. For such design temperatures, two tension tests on production type joints are required, one at the design temperature and one at $1.05T$ where

T = the design temperature, °F (°C)

Neither of these production type joints shall fail in the braze metal.

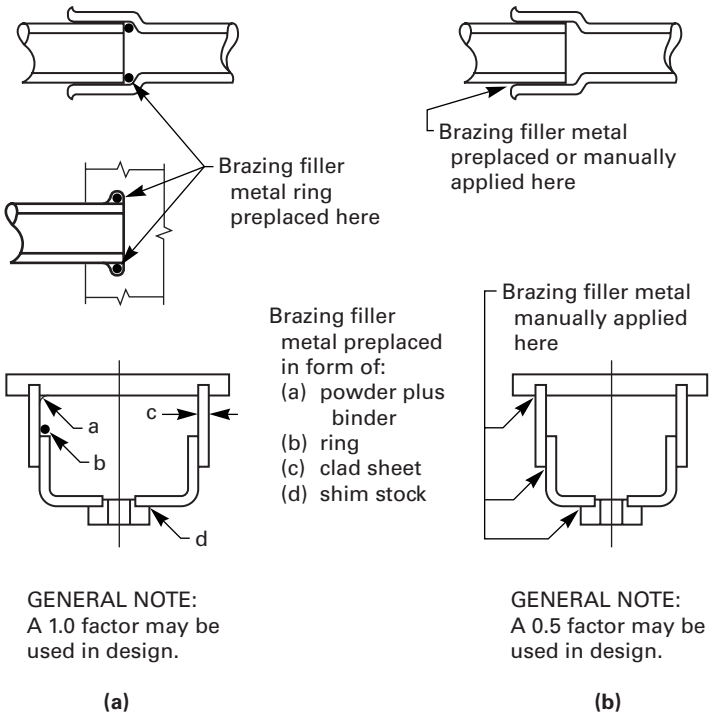
UB-13 CORROSION

(a) Provision shall be made for corrosion in accordance with the requirements in UG-25.

(b) Corrosion of the brazing filler metal and galvanic action between the brazing filler metal and the base metals shall be considered in selecting the brazing filler metal.

(c) The plate thickness in excess of that computed for a seamless vessel taking into account the applicable loadings in UG-22 may be taken as allowance for

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01 FIG. UB-14 EXAMPLES OF FILLER METAL APPLICATION

corrosion in vessels that have longitudinal joints of double-strap butt joint construction. Additional corrosion allowance shall be provided when needed, particularly on the inner buttstraps.

(d) The rules in this Part are not intended to apply to brazing used for the attachment of linings of corrosion resistant material that are not counted on to carry load.

UB-14 JOINT EFFICIENCY FACTORS

(a) The joint efficiency factor to be used in the design of pressure vessels and parts thereof shall be 1.0 for joints in which visual examination assures that the brazing filler metal has penetrated the entire joint [see Fig. UB-14 sketch (a)].

(b) The joint efficiency factor to be used in the design of pressure vessels and parts thereof shall be 0.5 for joints in which visual examination will not provide proof that the brazing filler metal has penetrated the entire joint. [See Fig. UB-14 sketch (b); UB-15(b) and (c).]

UB-15 APPLICATION OF BRAZING FILLER METAL

(a) The design shall provide for the application of the brazing filler metal as part of the design of the joint. Where practicable, the brazing filler metal shall be applied in such a manner that it will flow into the joint or be distributed across the joint and produce visible evidence that it has penetrated the joint.

(b) Manual Application. The manual application of the brazing filler metal by face feeding to a joint should be from the one side only. Visual observation of the other side of the joint will then show if the required penetration of the joint by the filler metal has been obtained. If the side opposite to the filler metal application cannot be visually examined, as is the case with socket type joints in pipe and tubing (blind joint), a joint efficiency factor of 0.5 shall be used in design of this joint as provided in UB-14(b).

(c) Preplaced Brazing Filler Metal. The brazing filler metal may be preplaced in the form of slugs, powder, rings, strip, cladding, spraying or other means. After brazing, the brazing filler metal should be visible on both sides of the joint. If the brazing filler metal is

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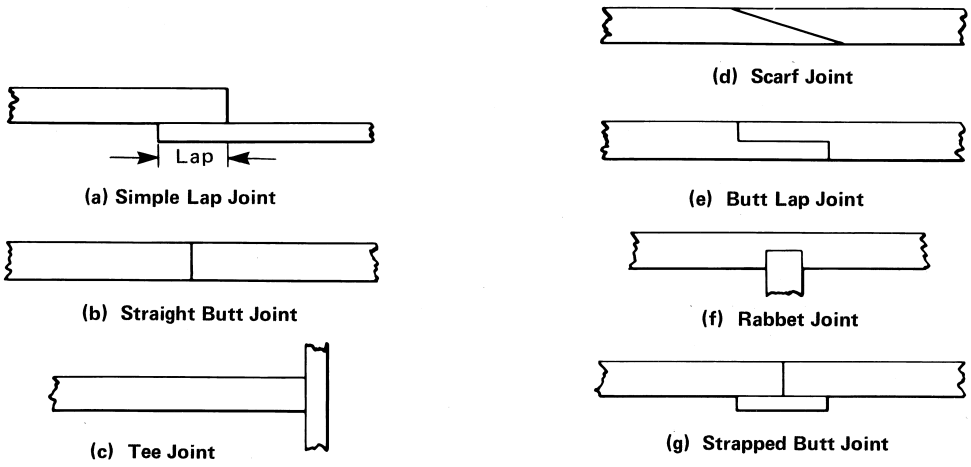


FIG. UB-16 SOME ACCEPTABLE TYPES OF BRAZED JOINTS
Other Equivalent Geometries Yielding Substantially Equal Results Also Are Acceptable

preplaced within a blind joint in such a manner that it penetrates the major portion of the joint during brazing and appears at the visible side of the joint, a joint efficiency factor of 1.0 may be used in the design of the joint. If the brazing filler metal is preplaced on the outside or near the outside of a blind joint, and the other side cannot be inspected to ascertain complete penetration, then a joint efficiency factor of 0.5 shall be used in the design of the joint as provided in UB-14(b). Figure UB-14 illustrates a few examples of this rule.

UB-16 PERMISSIBLE TYPES OF JOINTS

(a) Some permissible types of brazed joints are shown in Fig. UB-16. For any type of joint, the strength of the brazed section shall exceed that of the base metal portion of the test specimen in the qualification tension tests provided for in QB-150 of Section IX. Lap joints shall have a sufficient overlap to provide a higher strength in the brazed joint than in the base metal.

(b) The nominal thickness of base material used with lap joints tested using the test fixture shown in QB-462.1(e) shall not exceed $\frac{1}{2}$ in. (13 mm). There is no thickness limitation when specimens are tested without the test fixture shown in QB-462.1(e).

UB-17 JOINT CLEARANCE

The joint clearance shall be kept sufficiently small so that the filler metal will be distributed by capillary attraction. Since the strength of a brazed joint tends to decrease as the joint clearance used is increased, the clearances for the assembly of joints in pressure vessels or parts thereof shall be within the tolerances set up by the joint design and as used for the corresponding qualification specimens made in accordance with Section IX and UB-12 where applicable.

TABLE UB-17
RECOMMENDED JOINT CLEARANCES AT BRAZING TEMPERATURE

Brazing Filler Metal	Clearance, in. (mm) [Note (1)]
BAlSi	0.006–0.010 (0.15–0.25) for laps less than or equal to $\frac{1}{4}$ in. (6 mm) 0.010–0.025 (0.25–0.64) for laps greater than $\frac{1}{4}$ in. (6 mm)
BCuP	0.001–0.005 (0.02–0.13)
BAg	0.002–0.005 (0.05–0.13)
BCuZn	0.002–0.005 (0.05–0.13)
BCu	0.000–0.002 (0.05–0.13) [Note (2)]
BNi	0.001–0.005 (0.02–0.13)

NOTES:
(1) In the case of round or tubular members, clearance on the radius is intended.
(2) For maximum strength use the smallest possible clearance.

NOTE: For guidance, see Table UB-17 which gives recommended joint clearances at brazing temperature for various types of brazing filler metal. Brazing alloys will exhibit maximum unit strength if clearances are maintained within these limits.

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UB-18 JOINT BRAZING PROCEDURE

A joint brazing procedure shall be developed for each different type of joint of a brazed assembly. A recommended form for recording the brazing procedure is shown in QB-482 of Section IX. If more than one joint occurs in a brazed assembly, the brazing sequence shall be specified on the drawing or in instructions accompanying the drawing. If welding and brazing are to be done on the same assembly, the welding shall precede the brazing unless it is determined that the heat of welding will not adversely affect the braze previously made.

UB-19 OPENINGS

(a) Openings for nozzles and other connections shall be far enough away from any main brazed joint so that the joint and the opening reinforcement plates do not interfere with one another.

(b) Openings for pipe connections in vessels having brazed joints may be made by inserting pipe couplings, not exceeding NPS 3 (DN 80), or similar devices in the shell or heads and securing them by welding, without necessitating the application of the restrictive stamping provisions of UG-116, provided the welding is performed by welders who have been qualified under the provisions of Section IX for the welding position and type of joint used. Such attachments shall conform to the rules for welded connections in UW-15 and UW-16.

UB-20 NOZZLES

(a) Nozzles may be integral or attached to the vessel by any of the methods provided for in UG-43.

(b) For nozzle fittings having a bolting flange and an integral flange for brazing, the thickness of the flange attached to the pressure vessel shall not be less than the thickness of the neck of the fitting.

UB-21 BRAZED CONNECTIONS

Connections, such as saddle type fittings and fittings inserted into openings formed by outward flanging of the vessel wall, in sizes not exceeding NPS 3 (DN 80), may be attached to pressure vessels by lap joints of brazed construction. Sufficient brazing shall be provided on either side of the line through the center of the opening parallel to the longitudinal axis of the shell to develop the strength of the reinforcement as prescribed in UG-41 through shear in the brazing.

UB-22 LOW TEMPERATURE OPERATION

Impact tests shall be made of the brazed joints in pressure vessels and parts thereof fabricated from materials for which impact tests are required in Subsection C. The tests shall be made in accordance with UG-84 except that terms referring to welding shall be interpreted as referring to brazing.

FABRICATION

UB-30 GENERAL

(a) The rules in the following paragraphs apply specifically to the fabrication of pressure vessels and parts thereof that are fabricated by brazing and shall be used in conjunction with the requirements for *Fabrication* in Subsection A, and with the specific requirements for *Fabrication* in Subsection C that pertain to the class of material used.

(b) Each manufacturer or contractor shall be responsible for the quality of the brazing done by his organization and shall conduct tests not only of the brazing procedure to determine its suitability to ensure brazes which will meet the required tests, but also of the brazers and brazing operators to determine their ability to apply the procedure properly.

(c) No production work shall be undertaken until both the brazing procedure and the brazers or brazing operators have been qualified.

(d) Brazers not in the employ of the Manufacturer (Certificate of Authorization Holder) may be used to fabricate pressure vessels constructed in accordance with this Division, provided all the following conditions are met.

(1) All Code construction shall be the responsibility of the Manufacturer.

(2) All brazing shall be performed in accordance with the Manufacturer's Brazing Procedure Specifications which have been qualified by the Manufacturer in accordance with the requirements of Section IX.

(3) All brazers shall be qualified by the Manufacturer in accordance with the requirements of Section IX.

(4) The Manufacturer's Quality Control System shall include as a minimum:

(a) a requirement for complete and exclusive administrative and technical supervision of all brazers by the Manufacturer;

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(b) evidence of the Manufacturer's authority to assign and remove brazers at his discretion without the involvement of any other organization;

(c) a requirement for assignment of brazer identification symbols;

(d) evidence that this program has been accepted by the Manufacturer's Authorized Inspection Agency which provides the inspection service.

(5) The Manufacturer shall be responsible for Code compliance of the vessel or part, including Code Symbol stamping and providing completed Data Report Forms.

UB-31 QUALIFICATION OF BRAZING PROCEDURE

(a) Each procedure of brazing that is to be followed in construction shall be recorded in detail by the Manufacturer. Each brazing procedure shall be qualified in accordance with Section IX and when necessary determined by design temperature, with the additional requirements of this Section.

(b) The procedure used in brazing pressure parts and in joining load-carrying nonpressure parts, such as all permanent or temporary clips and lugs, to pressure parts shall be qualified in accordance with Section IX.

(c) The procedure used in brazing nonpressure-bearing attachments which have essentially no load-carrying function (such as extended heat transfer surfaces, insulation support pins, etc.) to pressure parts shall meet the following requirements.

(1) When the brazing process is manual, machine, or semiautomatic, procedure qualification is required in accordance with Section IX.

(2) When the brazing is any automatic brazing process performed in accordance with a Brazing Procedure Specification (in compliance with Section IX as far as applicable), procedure qualification testing is not required.

(d) Brazing of all test coupons shall be conducted by the Manufacturer. Testing of all test coupons shall be the responsibility of the Manufacturer. Qualification of a brazing procedure by one Manufacturer shall not qualify that procedure for any other Manufacturer, except as provided in QW-201 of Section IX.

UB-32 QUALIFICATION OF BRAZERS AND BRAZING OPERATORS

(a) The brazers and brazing operators used in brazing pressure parts and in joining load-carrying nonpressure parts (attachments) to pressure parts shall be qualified in accordance with Section IX.

(1) The qualification test for brazing operators of machine brazing equipment shall be performed on a separate test plate prior to the start of brazing or on the first work piece.

(b) The brazers and brazing operators used in brazing nonpressure-bearing attachments, which have essentially no load-carrying function (such as extended heat transfer surfaces, insulation support pins, etc.), to pressure parts shall comply with the following.

(1) When the brazing process is manual, machine, or semiautomatic, qualification in accordance with Section IX is required.

(2) When brazing is done by any automatic brazing process, performance qualification testing is not required.

(c) Each brazer or brazing operator shall be assigned an identifying number, letter, or symbol by the Manufacturer which shall be used to identify the work of that brazer or brazing operator in accordance with UW-37(f).

(d) The Manufacturer shall maintain a record of the brazers and brazing operators showing the date and result of tests and the identification mark assigned to each. These records shall be certified by the Manufacturer and be accessible to the Inspector.

(e) Brazing of all test coupons shall be conducted by the Manufacturer. Testing of all test coupons shall be the responsibility of the Manufacturer. A performance qualification test conducted by one Manufacturer shall not qualify a brazer or brazing operator to do work for any other Manufacturer.

UB-33 BUTTSTRAPS

(a) Buttstraps shall be formed to the curvature of the shell with which they are to be used.

(b) When the buttstraps of a longitudinal joint do not extend the full length of a shell section, the abutting edges of the shell plate may be welded provided the length of the weld between the end of the buttstraps and the edge of the head or adjoining shell plate is not greater than four times the shell plate thickness. When so constructed, the restrictive stamping provisions of UG-116 shall not apply provided the welding is performed by welders who have been qualified under the provisions of Section IX for the welding position and type of joint used. The welds shall be completed before brazing is begun.

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UB-34 CLEANING OF SURFACES TO BE BRAZED

The surfaces to be brazed shall be clean and free from grease, paint, oxides, scale and foreign matter of any kind. Any chemical or mechanical cleaning method may be used that will provide a surface suitable for brazing.

UB-35 CLEARANCE BETWEEN SURFACES TO BE BRAZED

The clearances between surfaces to be brazed shall be maintained within the tolerances provided for by the joint design and used in the qualifying procedure. If greater tolerances are to be used in production, the joint must be requalified for those greater tolerances. The control of tolerances required may be obtained by using spot welding, crimping, or other means which will not interfere with the quality of the braze. If such means are employed in production, they must also be employed in qualification of procedure, brazer, and operator.

UB-36 POSTBRAZING OPERATIONS

Brazed joints shall be thoroughly cleaned of flux residue by any suitable means after brazing and prior to inspection.[1] Other postbrazing operations such as thermal treatments shall be performed in accordance with the qualified procedure.

UB-37 REPAIR OF DEFECTIVE BRAZING

Brazed joints which have been found to be defective may be rebrazed, where feasible, after thorough cleaning, and by employing the same brazing procedure used for the original braze. See UB-44. If a different brazing procedure is employed, i.e., torch repair of furnace brazed parts, a repair brazing procedure shall be established and qualified.

When a repair brazing procedure is established, it shall meet Section IX and other conditions set forth in this Section.

[1] Flux residues can be extremely corrosive as well as interfering with visual inspection.

INSPECTION AND TESTS

UB-40 GENERAL

The rules in the following paragraphs apply specifically to the inspection and testing of pressure vessels and parts thereof that are fabricated by brazing and shall be used in conjunction with the general requirements for *Inspection and Tests* in Subsection A and with the specific requirements for *Inspection and Tests* in Subsection C that pertain to the class of material used.

UB-41 INSPECTION DURING FABRICATION

The Manufacturer shall submit the vessel or other pressure parts for inspection at such stages of the work as may be designated by the Inspector.

UB-42 PROCEDURE

The Inspector shall assure himself that the brazing procedure for each type of joint being produced is qualified in accordance with the requirements of Section IX and when necessary the additional requirements of this Section. He shall satisfy himself that each joint been fabricated in accordance with the procedure. Where there is evidence of consistent poor quality, the Inspector shall have the right at any time to call for and witness tests of the brazing procedure.

UB-43 BRAZER AND BRAZING OPERATOR

(a) The manufacturer shall certify that the brazing on a vessel or part thereof has been done by brazers or brazing operators who are qualified under the requirements of Section IX and the Inspector shall assure himself that only qualified brazers or brazing operators have been used.

(b) The manufacturer shall make available to the Inspector a certified copy of the record of the qualification tests of each brazer and brazing operator. The Inspector shall have the right at any time to call for and witness tests of the ability of a brazer or brazing operator.

UB-44 VISUAL EXAMINATION

(a) Where possible, the Inspector shall visually inspect both sides of each brazed joint after flux residue

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removal. Where it is not possible to inspect one side of a brazed joint (blind joint), the Inspector shall check the design to determine that the proper joint factor has been employed, unless he can assure himself that the brazing filler metal has been preplaced in such a manner that it satisfies UB-15(b) and (c).

(b) There shall be evidence that the brazing filler metal has penetrated the joint. In a butt braze there shall be no concavity. The braze may be repaired or rebrazed.

(c) The presence of a crack in the brazing filler metal shall be cause for rejection. Dye penetrant inspection may be used if desired. The braze may be repaired or rebrazed. See UB-37.

(d) The presence of a crack in the base metal adjacent to a braze shall be cause for rejection even if the crack is filled with brazing alloy. Such cracking shall not be repaired.

(e) Pinholes or open defects in the braze shall be cause for rejection. The joint may be rebrazed.

(f) Rough fillets, particularly those with a convex appearance, are cause for rejection. Such joints may be repaired or rebrazed.

UB-50 EXEMPTIONS

Certain brazed joints regardless of their service temperatures may be exempt from the additional mechanical testing of this Section providing that the design application does not assume any benefit from the brazed joint strength. It shall, however, meet the requirements of those qualification tests required by Section IX of the Code.

MARKING AND REPORTS

UB-55 GENERAL

The provisions for marking and reports given in UG-115 through UG-120 shall apply without supplement to brazed pressure vessels and parts thereof.

PRESSURE RELIEF DEVICES

UB-60 GENERAL

The provisions for pressure relieving devices given in UG-125 through UG-136 shall apply without supplement to brazed pressure vessels.

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