

## Postfabrication Heat Treatment of Cold-formed Head 2

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Please help me understand whether post-fabrication heat treatment is required for a cold-formed head fabricated from A240-304L material. I have paraphrased the code parts from the Section VIII, Div. 1 code below:

- 1) UF-31(a) states that all forgings shall be heat treated (after all forging is complete) in accordance with the applicable material specification. In this case, it appears that the A240 material specification does not require any specific heat treatment.
- 2) UG-79(a) states that limits are provided on cold working of high alloy steels with tensile properties enhanced by heat treatment [see UHA-44].
- 3) UHA-44 contains requirements for post-fabrication heat treatment of cold-formed areas of pressure-retaining components manufactured of 304L SS. However, the solution-annealing heat treatment is only required when the design temperature is between 1,075 deg-F and 1,250 deg-F AND the forming strain exceeds 20% OR the design temperature exceeds 1,250 deg-F AND the forming strain exceeds 10%.

Am I correct that a vessel head fabricated from A240-304L and with a design temperature less than 1,075 deg-F does not require a post-fabrication heat treatment? If this is true, then it appears that Section VII, Div. 1 does not place any limit on the cold-forming strain for A240-304L material placed into service without a post-fab. stress-relieving heat treatment. Is there no consideration of the increase in dislocation density (and a corresponding reduction in toughness) due to cold-working?

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Have you reviewed UHA-44 below and not simply Table UHA-44? All of the information is there

### UHA-44 REQUIREMENTS FOR POSTFABRICATION HEAT TREATMENT DUE TO STRAINING

(a) The following rules shall apply in addition to general rules for forming given in UHA-40.

(1) If the following conditions prevail, the cold formed areas of pressure-retaining components manufactured of austenitic alloys shall be solution annealed by heating at the temperatures given in Table UHA-44 for 20 min/in. (20 min/25 mm) of thickness or 10min, whichever is greater, followed by rapid cooling:

(-a) the finishing-forming temperature is below the minimum heat-treating temperature given in

Table UHA-44; and

(-b) the design metal temperature and the forming strains exceed the limits shown in Table UHA-44.

(2) Forming strains shall be determined by the equations in Table UG-79-1.

(b) When forming strains cannot be calculated as shown in (a) above, the Manufacturer shall have the responsibility to determine the maximum forming strain. For flares,....

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metengr,

Thanks for your reply. Yes, I did review UHA-44. In the case I am dealing with, the design temperature of the head is 250-deg F. Therefore, the conditions of UHA-44(a)(1)(-b) do not apply (i.e. it is out of the range of temperatures requiring heat treatment per Table UHA-44). Since the forming strain CAN be calculated using the equation for double curvature listed in Table UG-79-1, then UHA-44(b) does not apply. My conclusion is that although the forming strain can be calculated in this case, the code does not specify a limit on cold working of A240-304L at a design temperature of 250-deg F.

The manufacturer tells me that they will cold-form the head without subsequent heat treatment. I was a bit surprised that they are not required to heat treat the head by code. When I go to confirm that the manufacturer is interpreting the code correctly, I fail to find that there is any limit to the extent of forming strain at all for this material at this design temperature. I just want to make sure that I am not missing something else in the code. Considering that the forming strain is on the order of 15% in this case, I am fairly confident that the manufacturer is correct. However, I would feel better if I could reference a limit in the code or at least know whether this is standard practice in the industry, if the code provides no limitation.

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Nicely, researched. The background behind thermal treatment after cold forming is to reduce susceptibility to stress corrosion cracking and strain induced precipitation hardening that can affect the creep behavior of certain austenitic stainless steels. For your case, if the exposure of the cold-formed head does not result in increased susceptibility to stress corrosion cracking (certain contaminants in service), no post forming thermal treatment is required. Remember, the Code provides guidance for minimum requirements and is not all inclusive.

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what if the M.O.C is SA 240 TP 316L....it doesn't require postfabrication heat treatment???If its low carbon it has same carbon (0.030) as SA 240 TP 304L.

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c8829,

Yes, 316L is missing from Table UHA-44. I guess that means no postfabrication heat treatment is required by code, regardless of design temperature. Perhaps this is due to differences in susceptibility to stress corrosion cracking or precipitation of deleterious phases such as carbides or ferrite during cold forming???? metengr, does it have to do with the fact that 316L has a lower Ferrite Number (FN) than 304L?

I guess the bottom line is that the code requires postfabrication heat treatment for austenitic stainless steels in order to reduce carbide or other phases formed during cold forming? The code doesn't seem to require postfabrication heat treatment for the purpose of reducing 'work hardening' (i.e. dislocation density), at least for austenitic SS? Metengr, do you have any comments on this reasoning?

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Post forming HT requirements in Table UHA-44 for austenitic steels (300 series) are applicable for design temperature exceeding 580 or 540 deg C  
For Section VIII Div 1 - 316L materials are permitted only up to 454 deg C  
While 316 is permitted up to 816 deg C

This is the reason 316L is not included in Table UHA-44

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