Extract from ASME BPVC-VIII-1-2013, BPVC-VIII-2-2013, ASME BPVC-IID-2013_Customary

PH-DT Engineering Office, CERN

CERN, May 4th 2015

Div 2 PART 5: DESIGN BY ANALYSIS REQUIREMENTS

- 5.1.1.3 The design-by-analysis procedures in Part 5 may only be used if the allowable stress from **Annex 3-A** evaluated at the design temperature is governed by time-independent properties unless otherwise noted in a specific design procedure.

- **Annex 3-A: Allowable Design Stresses:**

- 3-A.1 ALLOWABLE STRESS BASIS – ALL MATERIALS EXCEPT BOLTING

- 3-A.1.2 The allowable stresses to be used in this Division for all product forms except bolting are provided in the following tables of Section II, Part D.
- (a) Carbon Steel and Low Alloy Steel – **Section II, Part D, Table 5A**

• Section II, Part D:

- 2.7 TABLE 5A **Table 5A** provides allowable stresses for ferrous materials for Section VIII, Division 2 construction

- For carbon steel see:
- MANDATORY APPENDIX 10 BASIS FOR ESTABLISHING MAXIMUM ALLOWABLE STRESS VALUES FOR TABLES 5A AND 5B

Table 10-100
Criteria for Establishing Allowable Stress Values for Tables 5A and 5B

Product/Material	Below Room Temperature: Tensile Strength	Below Room Temperature: Yield Strength	Room Temperature and Above: Tensile Strength	Room Temperature and Above: Yield Strength	Room Temperature and Above: Stress Rupture	Room Temperature and Above: Creep Rate
All wrought or cast ferrous and nonferrous product forms except bolting, and except for austenitic stainless steel, high-nickel alloy steel, nickel, and nickel alloy product forms	$\frac{S_T}{2.4}$	$\frac{S_y}{1.5}$	$\frac{S_T}{2.4}$	$\frac{R_y S_y}{1.5}$	$\text{Min.}\left(F_{avg} S_{R\,avg}, 0.8\, S_{R\,min}\right)$	$1.0\ S_{c\ avg}$
All wrought or cast austenitic stainless steel, high-nickel alloy steel, nickel, and nickel alloy product forms except bolting [Note (1)]	$\frac{S_T}{2.4}$	$\frac{S_y}{1.5}$	$\frac{S_T}{2.4}$	$\text{Min.}\left(\frac{S_y}{1.5}, \frac{0.9 S_y R_y}{1.0}\right)$	$\text{Min.}\left(F_{avg} S_{R\,avg}, 0.8\, S_{R\,min}\right)$	$1.0\ S_{c\ avg}$

GENERAL NOTE: When using this stress basis criterion to determine the allowable stresses for a specific material as a function of temperature, the derived allowable stress at a higher temperature can never be greater than the derived allowable stress at a lower temperature.

NOTE:
(1) Due to the relatively low yield strength of these materials, these higher stress values were established at temperatures where the short-time tensile properties govern, to permit the use of these materials where slightly greater deformation is acceptable. The stress values in this range exceed $66\frac{2}{3}\%$ but do not exceed 90% of the yield strength at temperature. These stress values are not recommended for the flanges of gasketed joints or other applications where slight amounts of distortion can cause leakage or malfunction. Table Y-2 lists multiplying factors that, when applied to the yield strength values shown in Table Y-1, will give allowable stresses that will result in lower values of permanent strain.

• Section II, Part D:

- Now see the table below: you can note that, the values imposed by the Fermilab guideline document, come out from **table A** of **Section II, Part D**, which applies to Division 1, and not to Division 2 (for which Table 5A above applies):

- 2.1 TABLE 1A - Table 1A provides allowable stresses for ferrous1 materials used in Section I; Section III, Division 1, Classes 2 and 3; Section VIII, Division 1; and Section XII construction

Table 1-100
Criteria for Establishing Allowable Stress Values for Tables 1A and 1B

Product/Material	Room Temperature and Below		Above Room Temperature						
	Tensile Strength	Yield Strength	Tensile Strength		Yield Strength		Stress Rupture		Creep Rate
Wrought or cast ferrous and nonferrous	$\frac{S_T}{3.5}$	$^2/_3\ S_Y$	$\frac{S_T}{3.5}$	$\frac{1.1}{3.5} S_T R_T$	$^2/_3\ S_Y$	$^2/_3\ S_Y R_Y$ or $0.9\ S_Y R_Y$ [Note (1)]	$F_{avg} S_{R\ avg}$	$0.8\ S_{R\ min}$	$1.0\ S_C$
Welded pipe or tube, ferrous and nonferrous	$\frac{0.85}{3.5} S_T$	$^2/_3 \times 0.85\ S_Y$	$\frac{0.85}{3.5} S_T$	$\frac{(1.1 \times 0.85)}{3.5} S_T R_T$	$^2/_3 \times 0.85\ S_Y$	$^2/_3 \times 0.85\ S_Y R_Y$ or $0.9 \times 0.85\ S_Y R_Y$ [Note (1)]	$(F_{avg} \times 0.85)\ S_{R\ avg}$	$(0.8 \times 0.85)\ S_{R\ min}$	$0.85\ S_C$

NOTE:
(1) Two sets of allowable stress values may be provided in Table 1A for austenitic materials and in Table 1B for specific nonferrous alloys. The lower values are not specifically identified by a footnote. These lower values do not exceed two-thirds of the minimum yield strength at temperature. The higher alternative allowable stresses are identified by a footnote. These higher stresses may exceed two-thirds but do not exceed 90% of the minimum yield strength at temperature. The higher values should be used only where slightly higher deformation is not in itself objectionable. These higher stresses are not recommended for the design of flanges or for other strain sensitive applications.

ASME BPVC-VIII-1-2013 (Div. 1)

Allowable Stresses ASME Sect. II Part D

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for Sect. VIII, Div. 1

TABLE 1-100
CRITERIA FOR ESTABLISHING ALLOWABLE STRESS VALUES FOR TABLES 1A AND 1B

Product/Material	Room Temperature and Below		Above Room Temperature						
	Tensile Strength	Yield Strength	Tensile Strength		Yield Strength		Stress Rupture		Creep Rate
Wrought or cast ferrous and nonferrous	$\frac{S_T}{3.5}$	$\frac{2}{3} S_Y$	$\frac{S_T}{3.5}$	$\frac{1.1}{3.5} S_T R_T$	$\frac{2}{3} S_Y$	$\frac{2}{3} S_Y R_Y$ or $0.9 S_Y R_Y$ [Note (1)]	$F_{avg} S_{R\,avg}$	$0.8 S_{R\,min}$	$1.0 S_c$
Welded pipe or tube, ferrous and nonferrous	$\frac{0.85}{3.5} S_T$	$\frac{2}{3} \times 0.85 S_Y$	$\frac{0.85}{3.5} S_T$	$\frac{(1.1 \times 0.85)}{3.5} S_T R_T$	$\frac{2}{3} \times 0.85 S_Y$	$\frac{2}{3} \times 0.85 S_Y R_Y$ or $0.9 \times 0.85 S_Y R_Y$ [Note (1)]	$(F_{avg} \times 0.85) S_{R\,avg}$	$(0.8 \times 0.85) S_{R\,min}$	$0.85 S_c$

NOTE:
(1) Two sets of allowable stress values may be provided in Table 1A for austenitic materials and in Table 1B for specific nonferrous alloys. The lower values are not specifically identified by a footnote. These lower values do not exceed two-thirds of the minimum yield strength at temperature. The higher alternative allowable stresses are identified by a footnote. These higher stresses may exceed two-thirds but do not exceed 90% of the minimum yield strength at temperature. The higher values should be used only where slightly higher deformation is not in itself objectionable. These higher stresses are not recommended for the design of flanges or for other strain sensitive applications.

S_T	Tensile strength at room temperature
S_Y	Yield strength (0.2%) at room temperature
R_T	ratio of the average temperature dependent trend curve value of tensile strength to the room temperature tensile strength
R_Y	ratio of the average temperature dependent trend curve value of yield strength to the room temperature yield strength
S_{Rave}	Ave. rupture stress 100,000 hours
S_{Rmin}	Min. rupture stress 100,000 hours
S_C	Ave. stress to cause a creep rate of 0.01%/1,000 hours
F_{avg}	Below 815°C = 0.67

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ASME BPVC-VIII-1-2013 (Div. 2)

Allowable Stresses ASME Sect. II Part D

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TABLE 10-100
CRITERIA FOR ESTABLISHING ALLOWABLE STRESS VALUES FOR TABLES 5A AND 5B

Product/Material	Below Room Temperature		Room Temperature and Above			
	Tensile Strength	Yield Strength	Tensile Strength	Yield Strength	Stress Rupture	Creep Rate
All wrought or cast ferrous and nonferrous product forms except bolting	$\frac{S_T}{2.4}$	$\frac{S_y}{1.5}$	$\frac{S_T}{2.4}$	$\frac{R_y S_y}{1.5}$	Min. $\left(F_{avg} S_{R\,avg},\ 0.8 S_{R\,min}\right)$	$1.0 S_{C\,avg}$
All wrought or cast austenitic and similar nonferrous product forms except bolting [Note (1)]	$\frac{S_T}{2.4}$	$\frac{S_y}{1.5}$	$\frac{S_T}{2.4}$	Min. $\left(\frac{S_y}{1.5},\ \frac{0.9 S_y R_y}{1.0}\right)$	Min. $\left(F_{avg} S_{R\,avg},\ 0.8 S_{R\,min}\right)$	$1.0 S_{C\,avg}$

GENERAL NOTE: When using this stress basis criterion to determine the allowable stresses for a specific material as a function of temperature, the derived allowable stress at a higher temperature can never be greater than the derived allowable stress at a lower temperature.

NOTE:

(1) Two sets of allowble stress values are provided in Table 5A for austenitic materials and in Table 5B for specific nonferrous alloys. The lower values are not specifically identified by a footnote. These lower values do not exceed two-thirds of the minimum yield strength at temperature. The higher alternative allowable stresses are identified by a footnote. These higher stresses may exceed two-thirds but do not exceed 90% of the minimum yield strength at temperature. The higher values should be used only where slightly higher deformation is not in itself objectionable. These higher stresses are not recommended for the design of flanges or other strain-sensitive applications.

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Div 2 PART 5: DESIGN BY ANALYSIS REQUIREMENTS

- **Annex 3-A: Allowable Design Stresses:**
- 3-A.2 ALLOWABLE STRESS BASIS – BOLTING MATERIALS
- 3-A.2.1
- The materials that may be used in this Division for bolting are shown below.
- … (d) Bolting Materials for Design in Accordance With Part 5 of this Division – Table 3-A.11

- 3-A.2.2
- The allowable stresses to be used in this Division for bolting are provided in the following tables of Section II, Part D.
- …..
- (d) Bolting Materials for Design in Accordance With Part 5of this Division – **Section II, Part D, Table 4**

Section II, Part D = ASME BPVC-IID-2013_Customary

- **Section II, Part D:** bolting materials
- 2.6 TABLE 4 **Table 4** provides design stress intensities for bolting materials used in Section III, Division 1, Classes 1, TC, and SC; and in Section VIII, Division 2 (using Part 5 an

- See also :
- MANDATORY APPENDIX 2 BASIS FOR ESTABLISHING DESIGN STRESS INTENSITY VALUES FOR TABLES 2A, 2B, AND **4,** AND ALLOWABLE STRESS VALUES FOR TABLE 3 -

- With in particular there:

- Appendix 2- section 2-130: CRITERIA FOR BOLTING MATERIALS FOR USE WITH PART 5 AND ANNEX 5.F OF SECTION VIII, DIVISION 2 AND SECTION III, SUBSECTIONS NB AND WB
- The design stress intensity value shown at any temperature in **Table 4** is the least of the following, with credit being granted for enhancement of properties by heat treatment or by strain hardening:
- (a) one-third of the specified minimum yield strength at room temperature;
- (b) one-third of the yield strength at temperature.
- d Annex 5.F of Section VIII, Division 2).

Section II, Part D = ASME BPVC-IID-2013_Customary

- **Section II, Part D:** bolting materials

Table 2-100(c)
Criteria for Establishing Design Stress Intensity Values for Table 4

Product/Material	Tensile Strength		Yield Strength	
Bolting, with strength enhanced by heat treatment or strain hardening	NA	NA	$\frac{1}{3} S_Y$	$\frac{1}{3} S_Y R_Y$

- **But, in section 5.7 of Division 2, we find:**

- **5.7 SUPPLEMENTAL REQUIREMENTS FOR BOLTS**
- 5.7.1 Design Requirements.
- (a) The number and cross-sectional area of bolts required to resist the design pressure shall be determined in accordance with the procedures of paragraph 4.16. The allowable bolt stress shall be obtained from Part 3.

- 5.7.2 Service Stress Requirements. Actual service stress in bolts, such as those produced by the **combination of preload, pressure**, and differential expansion, **may be higher than the allowable stress values given in Annex 3-A.**
- (a) The maximum value of service stress, averaged across the bolt cross section and neglecting stress concentrations, shall not **exceed two times the allowable stress values** in paragraph 3-A.2.2 of Annex 3-A.
- (b) The maximum value of service stress, except as restricted by paragraph 5.7.3.1(b) at the periphery of the bolt cross section resulting from direct tension plus bending and neglecting stress concentrations, shall not exceed **three times the allowable stress values** in paragraph 3-A.2 of Annex 3-A. When the bolts are tightened by methods other than heaters, stretchers, or other means which minimize residual torsion, the stress measure used in the evaluation shall be the equivalent stress as defined in Equation (5.1).
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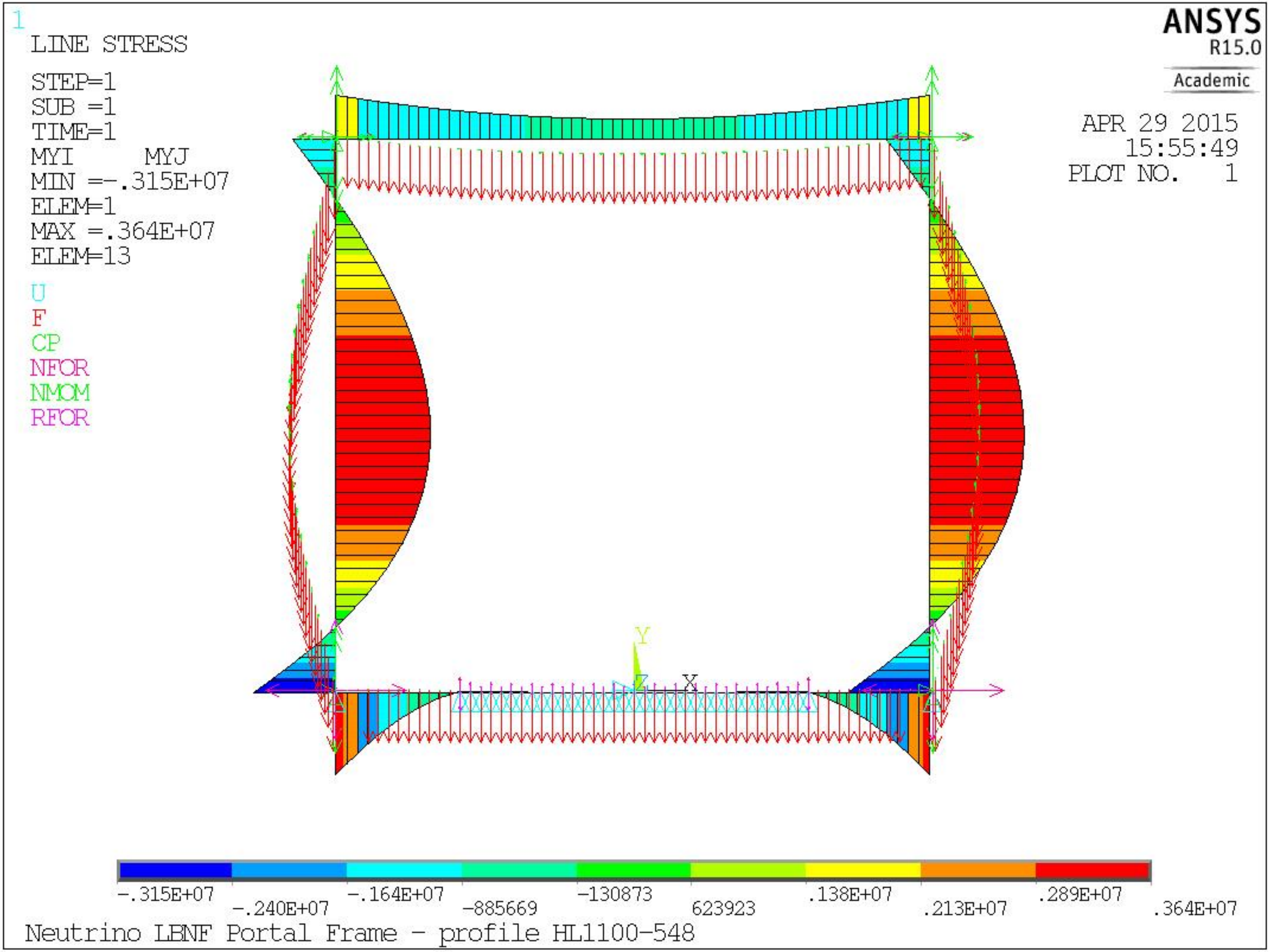
Steel Grades

- Steel S355 (EC properties for t>40mm)
  - σ_y=335 MPa $\rightarrow$ σ_y/1.5=223 MPa
  - UTS=470 MPa $\rightarrow$ UTS/3.5=134 MPa $\rightarrow$ UTS/2.4=195 MPa

- Small Improvements by moving to S450 (EC properties for t>40mm):
  - σ_y=410 MPa $\rightarrow$ σ_y/1.5=273.3 MPa
  - UTS=550 MPa $\rightarrow$ UTS/3.5=157 MPa $\rightarrow$ UTS/2.4 =229 MPa

Material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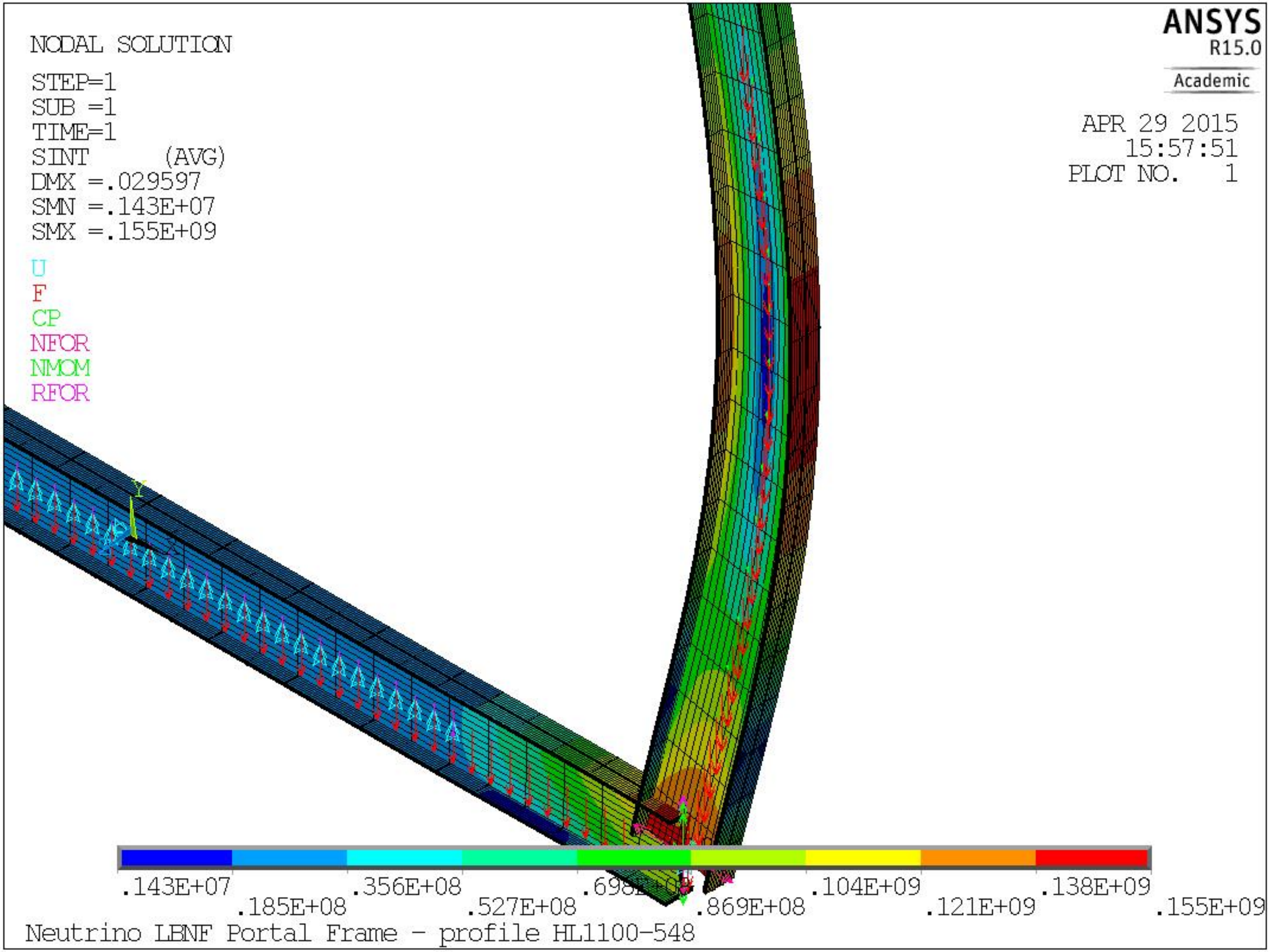
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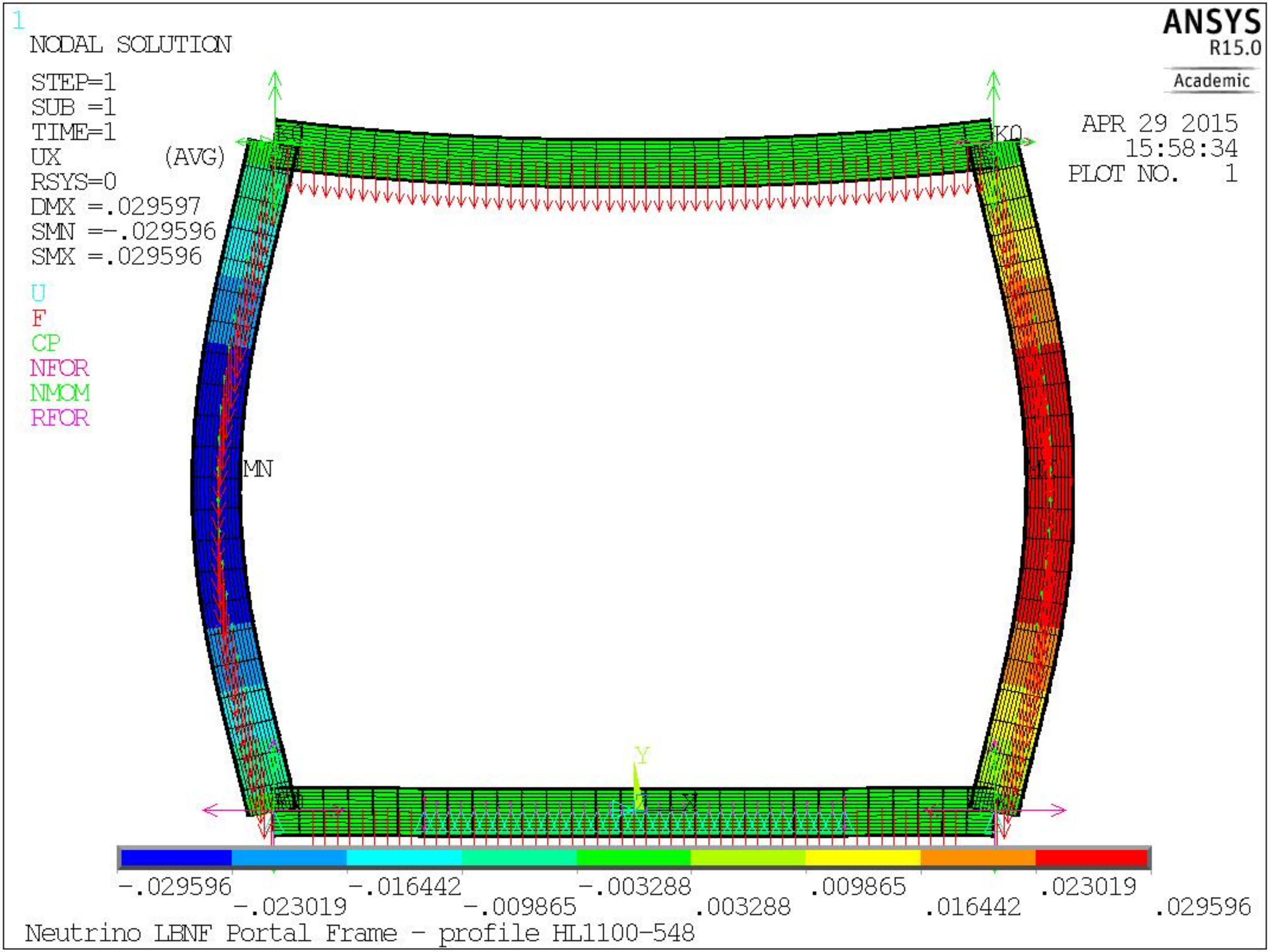
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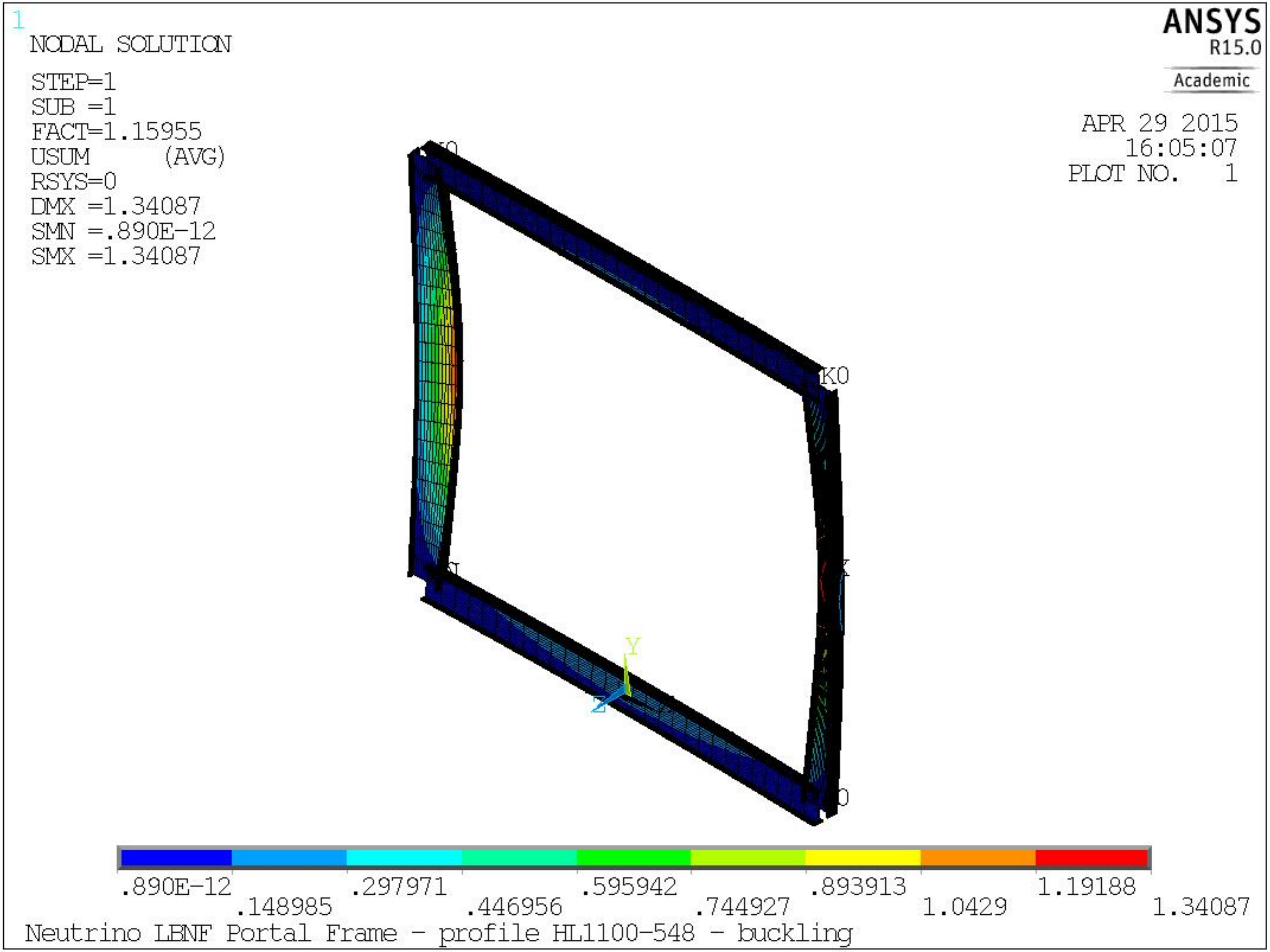
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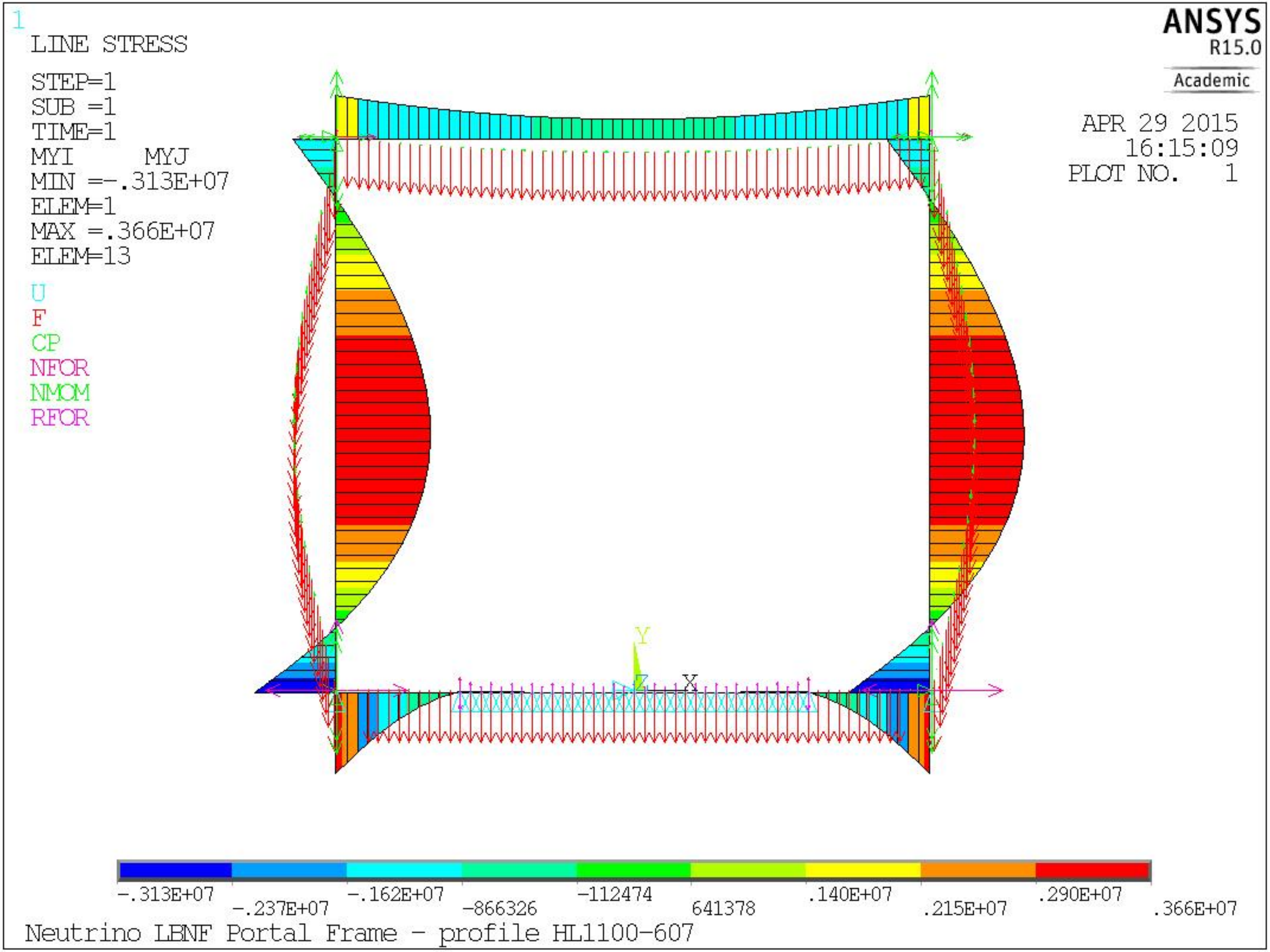
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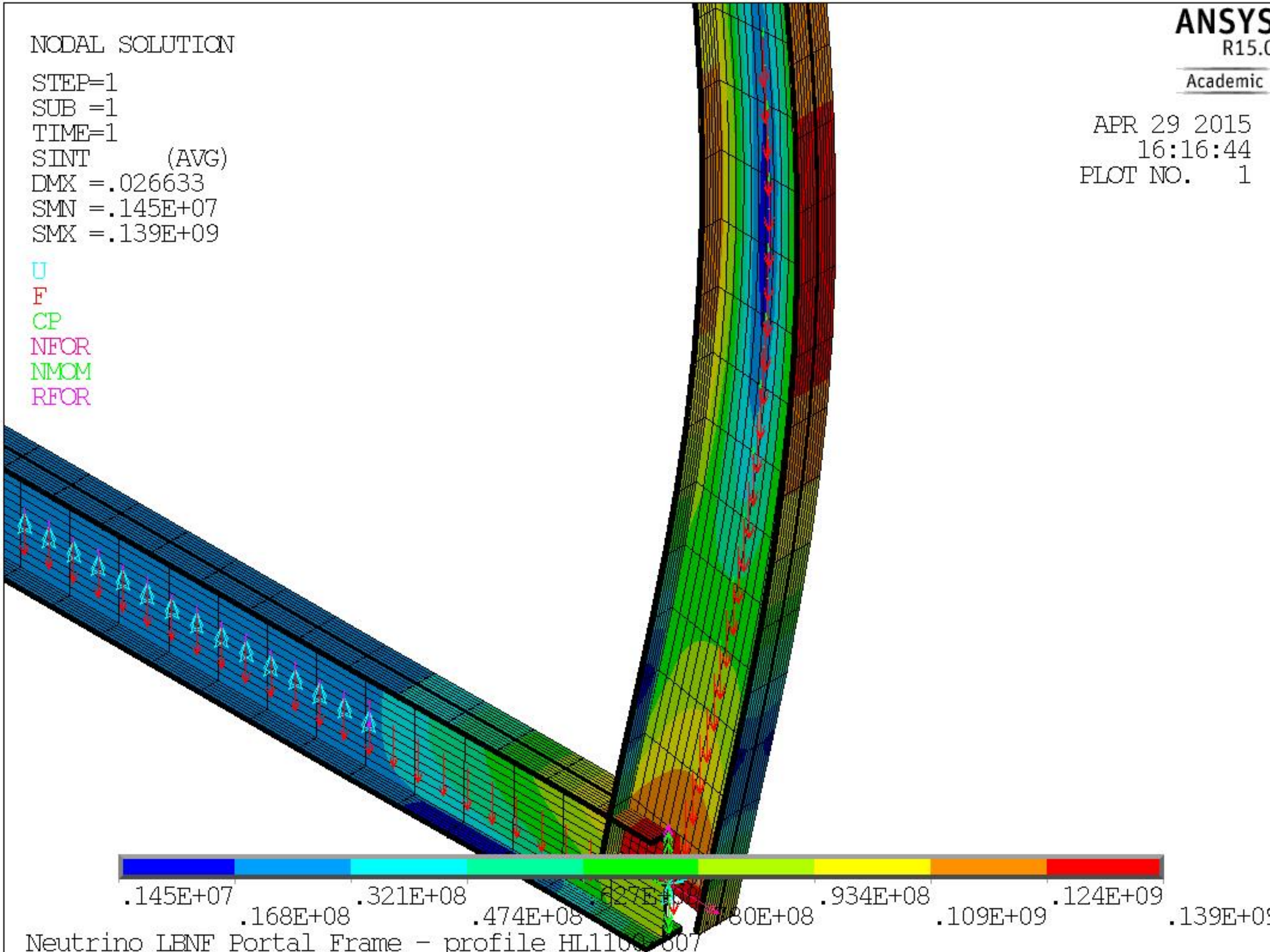
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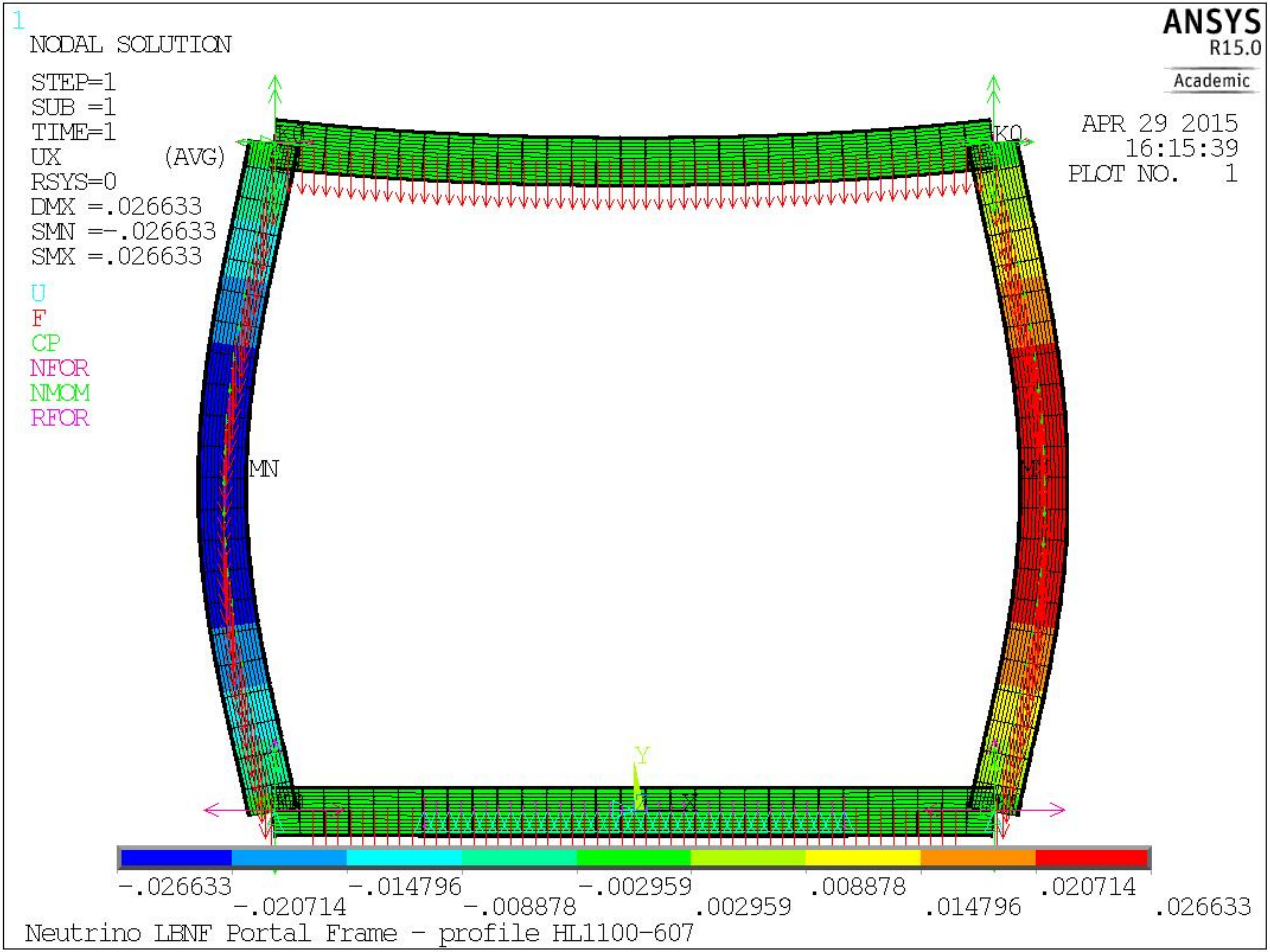
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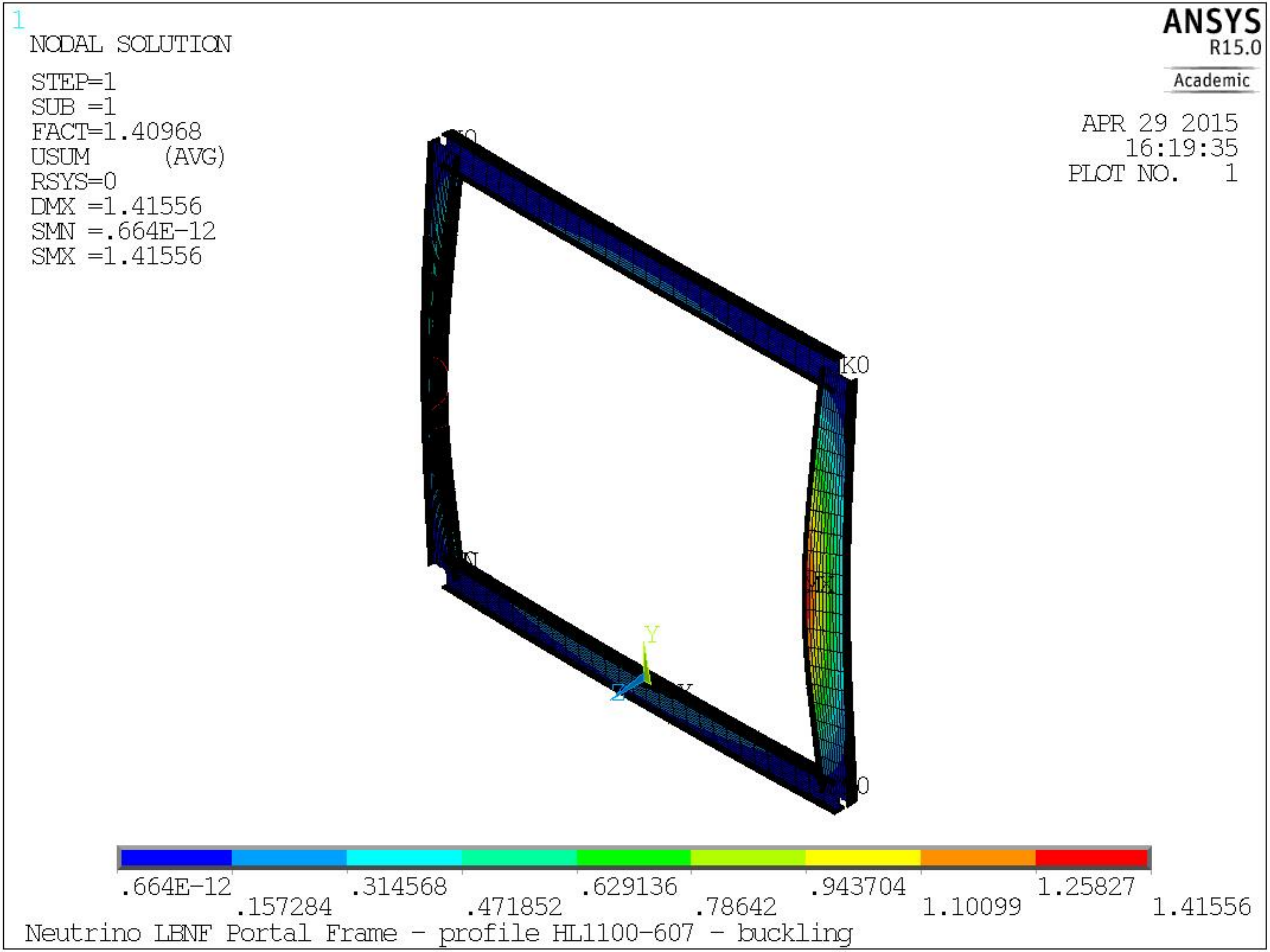
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