**PACKER ENGINEERING INC,**
1950 North Washington Street,
Naperville, IL 60566

# Forensic Evaluation of Pressure Relief Devices
**P.E. Project No. 502023**

FINAL REPORT

**May 2, 2011**

**Prepared for**
**Mark Toughiry**
**Office of Hazardous Materials Technology**
**Pipeline and Hazardous**
**Materials Safety Administration**
**U.S. Department of Transportation**

Purchase Order No. DTPH56-10-F-000007

# Table of Contents

## 1.0 INTRODUCTION

**Objective: -** The purpose of this solicitation was to perform forensic evaluation and documentation of six (6) pressure relief devices (PRDs) to evaluate the functionality of each valve.

### 1.1 Technical Approach

In this project, six PRDs labeled 08H127-1, 08H127-2, 08H127-3, 08H127-Exemplar, 08H127-4 and 08H127-5 were examined. The valves were visually documented and radiography was utilized on all six valves to document and attempt to visualize the internal conditions. The PRDs labeled as 08H127-1, 08H127-2, 08H127-3, and 08H127-Exemplar have a nominal set pressure rating of 150 psi (Note that 08H127-3 is missing a data plate but it is Packer's understanding that it has the same nominal set pressure as the 08H127-1, -2, and -Exemplar). These four (4) valves were manufactured by Kunkle. The PRDs labeled as 08H127-4 and 08H127-5 have a nominal set pressure rating of 250 psi. Packer was not provided with an exemplar valve comparable to the 08H127-4 and 08H127-5 PRDs. These two (2) valves were manufactured by Herose. Following visual inspection, documentation, and radiography, all six valves were tested to determine their actual relief pressures.

## 2.0 GENERAL DOCUMENTATION OF THE PRDs

### 2.1 Visual Documentation and PRD Specifications

**1) PRD – Labeled : 08H127-1 (Kunkle)**

The PRD labeled 08H127-1 is as shown in Figures 1 to 14. The following markings were observed on this PRD.

- Kunkle valve div
- Assembly by LAM Valves inc Houston Tx
- Mod: 912BFEMO1-KE
- SET:150 Psi CAP: 974 SCFM
- Size : 1
- S/N : I-80283-1B
- Factory appointed by assembler

**2) PRD – Labeled : 08H127-2 (Kunkle)**

The PRD labeled 08H127-2 is as shown in Figures 15 to 24. The following markings were observed on this PRD.

- Kunkle valve div
- Assembly by LAM Valves inc Houston Tx
- Mod: 912BFEMO1-KE
- SET:150 Psi  CAP: 974 SCFM
- Size : 1
- S/N : I-80283-1A
- Factory appointed by assembler

**3) PRD – Labeled : 08H127-3 (Kunkle)**

The PRD labeled 08H127-3 is as shown in Figures 25 to 35. There was no marking found on this PRD.

**4) PRD – Labeled : 08H127-Exemplar (Kunkle)**

The PRD labeled 08H127 (exemplar) is as shown in Figures 36 to 48. The following markings were observed on this PRD.

- Kunkle valve div
- Assembly by LAM Valves inc Houston Tx
- Mod: 912BFEMO1-KE
- SET:150 Psi  CAP: 974 SCFM
- Size : 1
- S/N : I-28450
- Factory appointed by assembler

**5) PRD – Labeled : 08H127-4 (Herose)**

The PRD labeled 08H127-4 is as shown in Figures 49 to 61. The following markings were observed on this PRD.

- CH1300EG
- 1/4NPTF
- 1.4301
- PN 40
- CE0045
- CH1320L0
- TUV.SV.99.836.6.D/G.0.66
- 05.04 250 psi
- TYP 06474.$O_2$ – 196 ºC
- RG5

**6) PRD – Labeled : 08H127-5 (Herose)**

The PRD labeled 08H127-5 is as shown in Figures 62 to 73. The following markings were observed on this PRD.

- CH1367EG
- 1/4NPTF
- 1.4301
- PN 40
- CE0045
- CH1323L0
- TUV.SV.04.836.6.D/G.0.66
- 11.04 250 psi
- TYP 06474.$O_2$ – 196 ºC

Data sheets for both the Kunkle type 912 PRD and the Herose Type 06474 PRD are included as Appendix A.

## 2.2 Radiographic Inspection of PRDs

The Radiograph images of all PRD's are included in Appendix B. For valves 08H127-1, -2, -3, -Exemplar, the following information was acquired from the manufacturer, Kunkle Valve:

| | | |
|---|---|---|
| Spring wire diameter | = | 0.192 inches |
| Free length of spring | = | 2.19 inches |
| Coil Count | = | 5 active, 2 inactive |
| Spring rate | = | 372 lb/inch |

Based on the radiograph images various dimensions were estimated as shown in Table I. Scatter and other effects make the estimated dimensions from the radiographs inexact but it can be seen that the estimated wire diameter agrees reasonably well with the value provided by Kunkle. Thus the other dimensions are expected to be reasonable estimates of the actual values as well.

**TABLE I**
**PRD Dimensional Measurements**
**Values Estimated from Radiograph Images are Shaded**

| PRD | Overall Length | Wire Diameter | Coil Diameter | Mid-Coil spacing | Working Height | Solid Height |
|---|---|---|---|---|---|---|
| 08H127-Exemplar | 8.775 | 0.181 | 0.986 | 0.333 | 2.027 | 1.235 |
| 08H127-1 | 8.767 | 0.180 | 0.988 | 0.304 | 1.789 | 1.176 |
| 08H127-2 | 8.799 | 0.183 | 0.984 | 0.297 | 1.796 | 1.224 |
| 08H127-3 | 8.761 | 0.202 | 1.003 | 0.288 | 1.823 | 1.321 |
| 08H127-4 | 4.387 | 0.061 | 0.405 | 0.121 | 0.938 | 0.538 |
| 08H127-5 | 4.393 | 0.063 | 0.407 | 0.120 | 0.950 | 0.552 |

## 3.0 PRESSURE TESTING

Each of the six valves was installed on a pressure vessel. Pressure was applied using air (up to approximately 160 psig) and then additionally using compressed nitrogen as necessary. When any particular valve opened/relieved, the pressure was allowed to reduce until the valve reseated and then pressurization was repeated two more times (i.e. a total of 3 relief cycles). Some valves did not open in which case the testing was aborted for safety reasons. Each test was video taped.

## 4.0 RESULTS & DISCUSSION

Based on dimensions estimated from the radiographs, the data provided by Kunkle, and the presumption that valve 08H127-Exemplar was properly set at 150 psi nominal relief pressure, estimates of the current spring force and opening pressures for valves 08H127-1, -2, and -3 were made These results are given in Table II. Because no exemplar was provided for 08H127-4, and -5, equivalent estimates could not be made for those valves. It is noted, however, that the springs on 08H127-4 and -5 both appear to be compressed a very similar amount and thus their opening pressures would also be expected to be similar.

**TABLE II**
**Estimated Spring Force and Opening Pressure of the PRD's**

| PRD | Spring Working Height (in.) | Estimated Spring Force (lb) | Estimated Opening Pressure (psig) |
|---|---|---|---|
| 08H127-Exemplar | 2.027 | 61 | 150 |
| 08H127-1 | 1.789 | 149 | 369 |
| 08H127-2 | 1.796 | 147 | 363 |
| 08H127-3 | 1.823 | 137 | 338 |

The results of the pressure tests are presented in Table III and the associated graphs showing pressure vs. time are given in Appendix C. Packer Engineering was not provided details regarding the actual installation and usage for the valves that were tested. While the allowable variance in opening pressures for PRDs is dependent upon their use and installation conditions, a general rule is that PRDs are allowed a 10% over pressure beyond their rated value in order to open fully. This 10% over pressure value is also reflected in Table III. Detailed discussion of the results presented in Table III and possible reasons for these results are given in the conclusions section.

**TABLE III**
**Pressure Test Results**

| PRD | Marked Opening Pressure (psig) | Marked Opening Pressure plus 10% (psig) | Estimated Opening Pressure (psig) | Actual full opening pressure(s) (psig) | Opened Within Marked Opening Pressure Plus 10%? | Comments |
|---|---|---|---|---|---|---|
| 08H127-Exemplar | 150 | 165 | 150 | 156, 161, 160 | Yes | |
| 08H127-1 | 150 | 165 | 369 | 334, 310, 310 | NO | |
| 08H127-2 | 150 | 165 | 363 | Failed to open | NO | Max pressure = 378 |
| 08H127-3 | 150* | 165 | 338 | Failed to open | NO | Max pressure = 375 |
| 08H127-4 | 250 | 275 | N/A | 260, 258, 259 | Yes | |
| 08H127-5 | 250 | 275 | N/A | Failed to open | NO | Max pressure = 305** |

* No markings on valve, assumed to be the same as 08H127-1 and 08H127-2

** Maximum test pressure limited to approximately 300 psi per direction from client.

## 5.0 CONCLUSIONS

The pressure testing showed that four (4) of the five (5) subject PRDs failed to open before exceeding the nominal set pressure by at least 10 percent. Of those four, only one actually opened. For several of the valves it appears that the set points were intentionally changed from their as-manufactured settings. These include 08H127-1,2, 3 and possibly 5. Detailed conclusions regarding each valve are given below.

- PRD 08H127-Exemplar is considered to be the "standard" for the three other comparable PRDs (08H127-1, -2, and -3). It has a nominal set point of 150 psi and opened fully between 156 and 161 psig. Since the allowable variance in opening pressures for PRDs is dependent upon their use and installation conditions, it is not possible to state definitively that this valve "met specifications" because those specifications and its intended use are unknown. A general rule, however, is that PRDs used for unfired applications are allowed a 10% over pressure beyond their rated value in order to open fully. Thus for a nominal 150 psi opening pressure it would be allowable for the pressure to reach 165 psi before this valve opened fully. Based on this rule of thumb, the exemplar valve behaved as expected.
- PRD 08H127-1 opened fully when tested but the pressures required exceeded the nominal 150 psi set point by a factor of 2.07-2.23 (107%-123% over rated set point). The increased set point is consistent with the radiographic images showing that the internal spring is compressed more than the exemplar PRD (which operated as expected). The manufacturer's seal wire was broken on this valve. The broken seal wire, overly compressed spring, and associated increased set point indicate that the opening pressure was intentionally changed from its as-manufactured condition.
- PRD 08H127-2 failed to open at all even when pressurized to a value of 378 psi which is 2.52 times (152% over) the nominal 150 psig set point. Based on the radiographic images, this PRD could be expected to behave similarly to 08H127-1. Since it did not behave similarly, however, it is likely that there is internal binding and/or sticking in addition to the internal spring being compressed more than the exemplar PRD. Even without any sticking or binding this valve would not be expected to open at the nominal 150 psi rating on the manufacturer's tag. The manufacturer's seal wire was broken on this valve. The broken seal wire and overly compressed spring indicate that the opening pressure was intentionally changed from its as-manufactured condition.
- PRD 08H127-3 failed to open at all even when pressurized to a value of 375 psi which is 2.50 times (150% over) the nominal 150 psig set point. Based on the radiographic images, this PRD could be expected to open at less pressure than 08H127-1 and 8H127-2 but still more than the exemplar PRD. Since it did not open at less pressure, however, it is likely that there is internal binding and/or sticking in addition to the internal spring being compressed more than the exemplar PRD. Even without any sticking or binding this valve would not

be expected to open at the presumed 150 psi rating (the manufacturer's tag was missing on this valve). The manufacturer's seal wire was broken on this valve. The broken safety seal and overly compressed spring indicate that the opening pressure was intentionally changed from its as-manufactured condition.

- PRD 08H127-4 had a nominal set point of 250 psi and opened fully between 259-260 psig. Since the allowable variance in opening pressures for PRDs is dependent upon their use and installation conditions, it is not possible to state definitively that this valve "met specifications" because those specifications and its intended use are unknown. A general rule, however, is that PRDs used for unfired applications are allowed a 10% over pressure beyond their rated value in order to open fully. Thus for a nominal 250 psi opening pressure it would be allowable for the pressure to reach 275 psi before this valve opened fully. Based on this rule of thumb, the valve behaved as expected. The manufacturer's seal wire was intact on this valve.
- PRD 08H127-5 failed to open at all even when pressurized to a value of 305 psi (1.22 times/22% over the nominal 250 psig set point). Using the general rule previously described, this value exceeds the 10% overpressure allowance that might be expected dependent upon use and application. Despite this, the radiographic images indicate that the spring in this valve is compressed similarly to that in 08H127-4 and thus that similar opening pressures could be expected. Since this valve (08H127-5) did not open, however, it is likely that there is internal sticking or binding. The manufacturer's seal wire was broken on this valve. The reason for the wire being broken is not known and based on current information it does not appear that the set point on this valve was significantly changed from its as-manufactured condition. The reasons that this valve failed to open at a pressure comparable to 08H127-4 are currently unknown.

This completes Packer Engineering's work on this project. Please feel free to call with any questions or comments. Thank you for choosing Packer Engineering.

Sincerely,

PACKER ENGINEERING, INC.

Mridula L Pareek
Engineering Technologist

John E Myers, Ph.D., P.E.*
Technical Vice President

* Registered professional Engineer in the state of Wisconsin

## 6.0 FIGURES


**Figure 1: Shows the as received PRD identified as 08H127-1**

**Figure 2: Shows the as received PRD identified as 08H127-1**


**Figure 3: Shows PRD identified as 08H127-1**


**Figure 4: Shows PRD identified as 08H127-1**

**Figure 5: Shows PRD identified as 08H127-1**

**Figure 6: Shows PRD identified as 08H127-1**


**Figure 7: Shows PRD identified as 08H127-1**

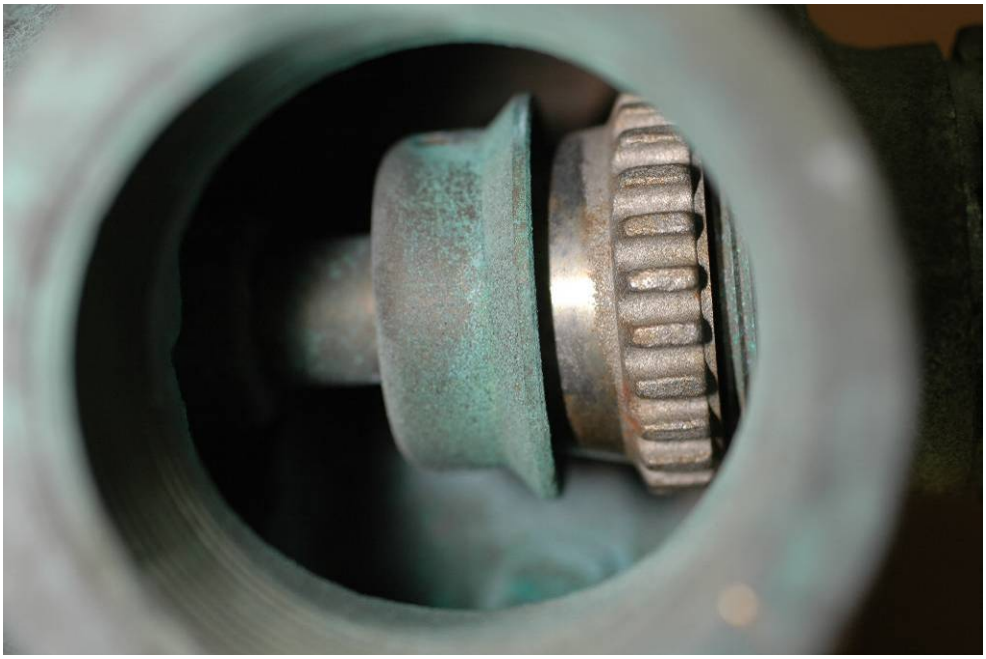


**Figure 8: Shows PRD identified as 08H127-1**

**Figure 9: Shows PRD identified as 08H127-1**


**Figure 10: Shows PRD identified as 08H127-1**


**Figure 11: Shows PRD identified as 08H127-1**


**Figure 12: Shows PRD identified as 08H127-1**

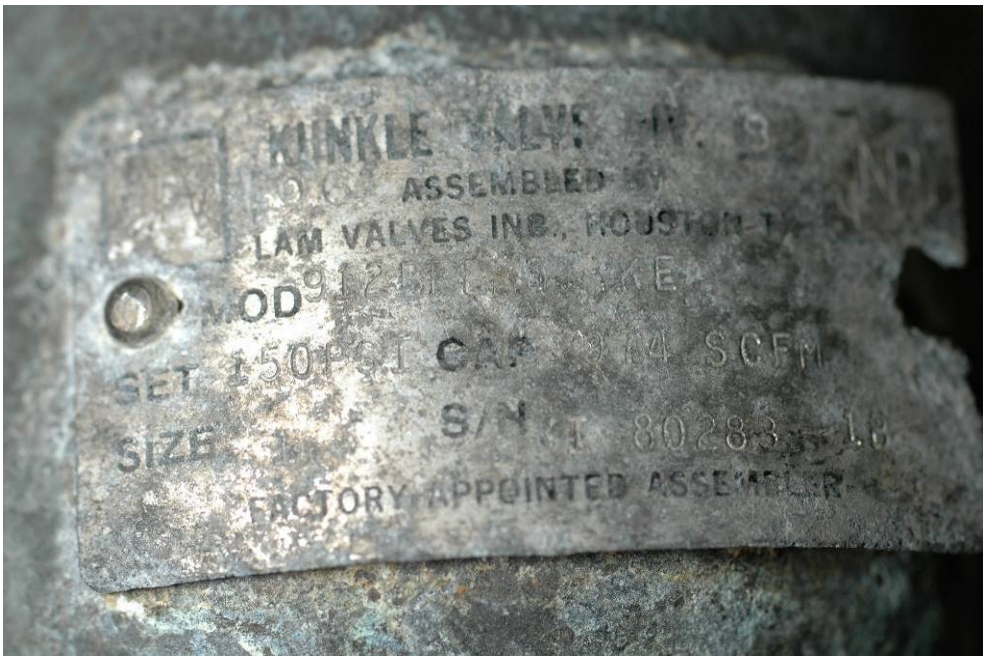



**Figure 13: Shows PRD identified as 08H127-1**

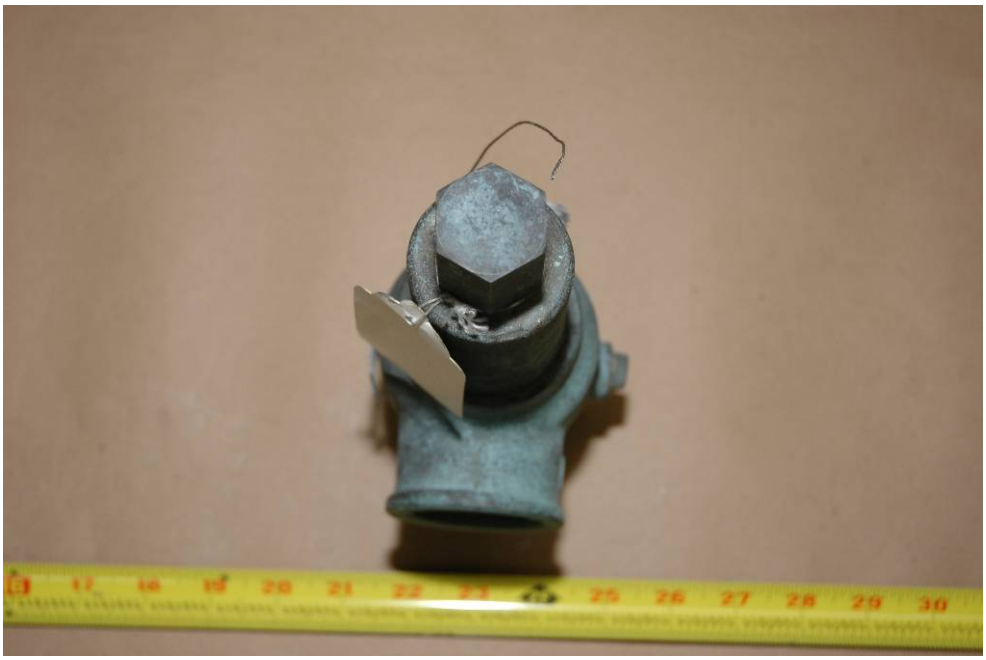


**Figure 14: Shows PRD identified as 08H127-1**


**Figure 15: Shows the as received PRD identified as 08H127-2**

**Figure 16: Shows the as received PRD identified as 08H127-2**


**Figure 17: Shows PRD identified as 08H127-2**

**Figure 18: Shows PRD identified as 08H127-2**


**Figure 19: Shows PRD identified as 08H127-2**

**Figure 20: Shows PRD identified as 08H127-2**

**Figure 21: Shows PRD identified as 08H127-2**

**Figure 22: Shows PRD identified as 08H127-2**


**Figure 23: Shows PRD identified as 08H127-2**

**Figure 24: Shows PRD identified as 08H127-2**


**Figure 25: Shows the as received PRD identified as 08H127-3**

**Figure 26: Shows the as received PRD identified as 08H127-3**


**Figure 27: Shows PRD identified as 08H127-3**

**Figure 28: Shows PRD identified as 08H127-3**

**Figure 29: Shows PRD identified as 08H127-3**


**Figure 30: Shows PRD identified as 08H127-3**

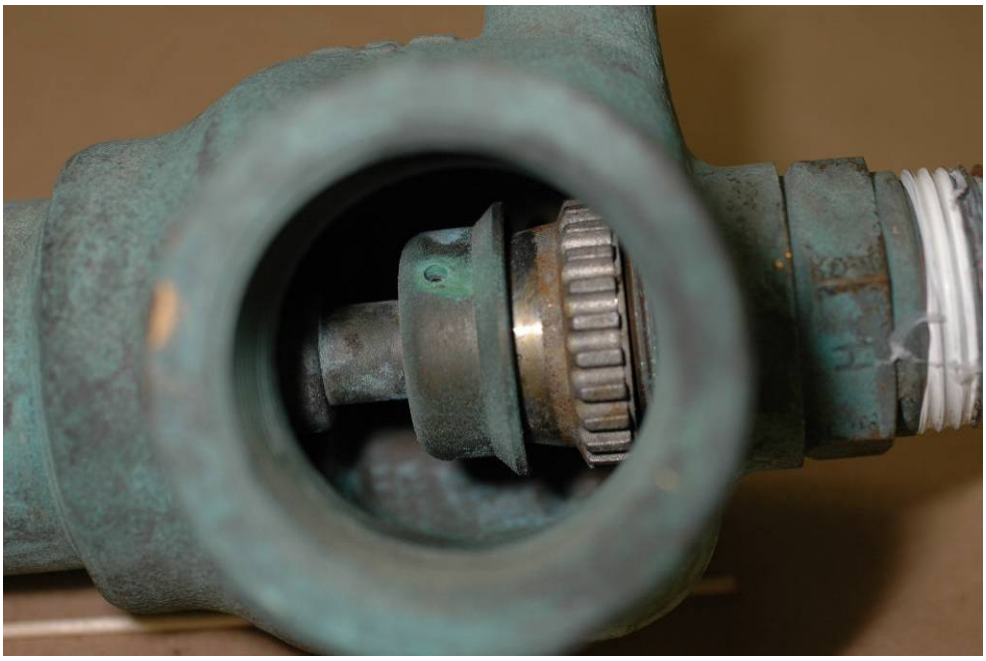


**Figure 31: Shows PRD identified as 08H127-3**

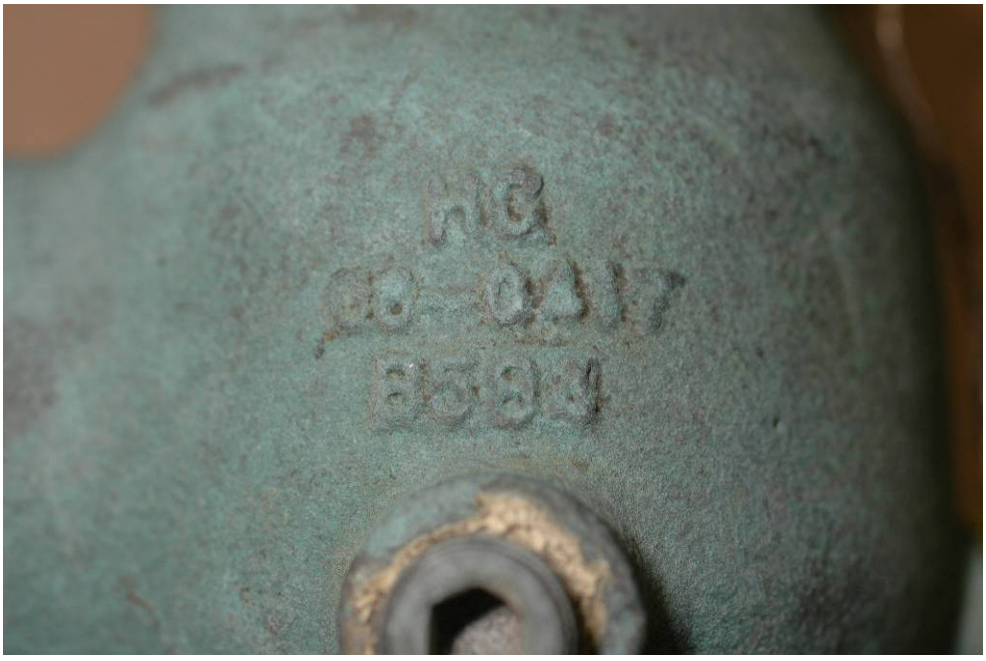


**Figure 32: Shows PRD identified as 08H127-3**

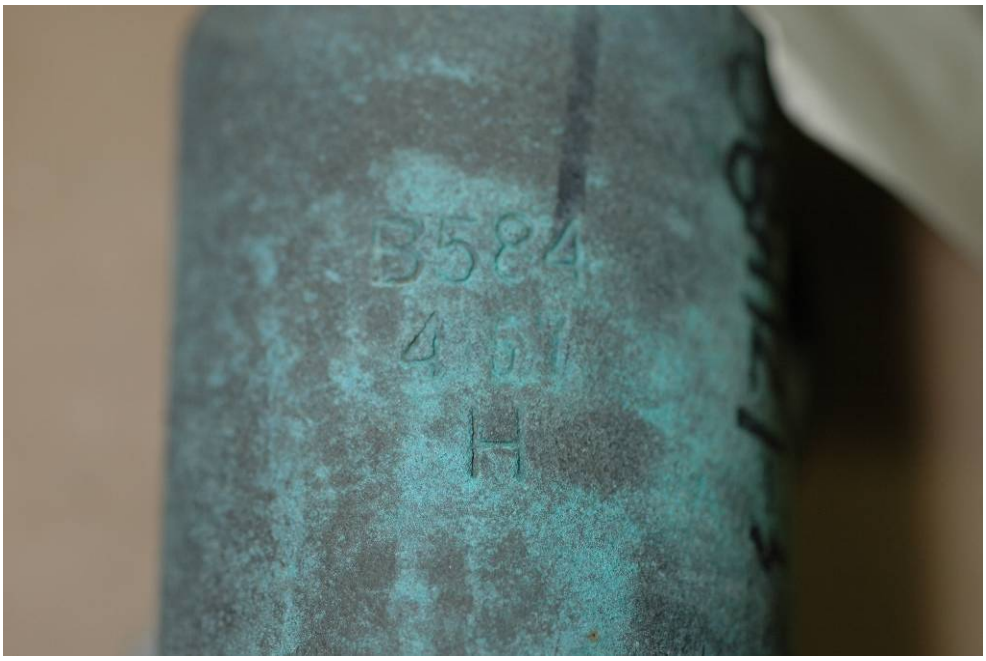



**Figure 33: Shows PRD identified as 08H127-3**

**Figure 34: Shows PRD identified as 08H127-3**


**Figure 35: Shows PRD identified as 08H127-3**

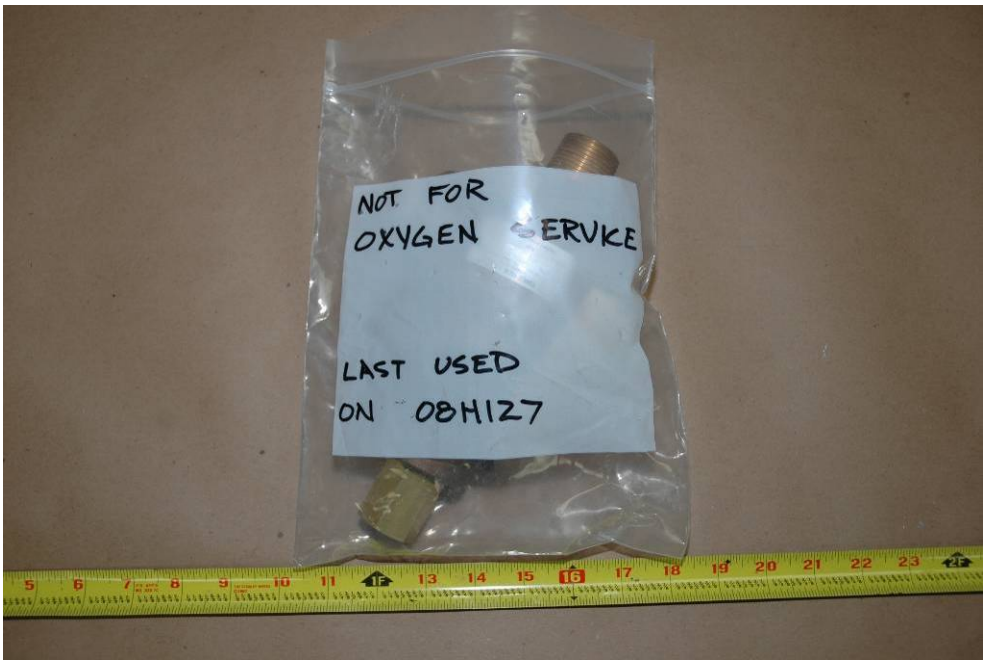



**Figure 36: Shows the as received PRD identified as 08H127-Exemplar**

**Figure 37: Shows the as received PRD identified as 08H127-Exemplar**

**Figure 38: Shows PRD identified as 08H127-Exemplar**

**Figure 39: Shows PRD identified as 08H127-Exemplar**

**Figure 40: Shows PRD identified as 08H127-Exemplar**


**Figure 41: Shows PRD identified as 08H127-Exemplar**

**Figure 42: Shows PRD identified as 08H127-Exemplar**

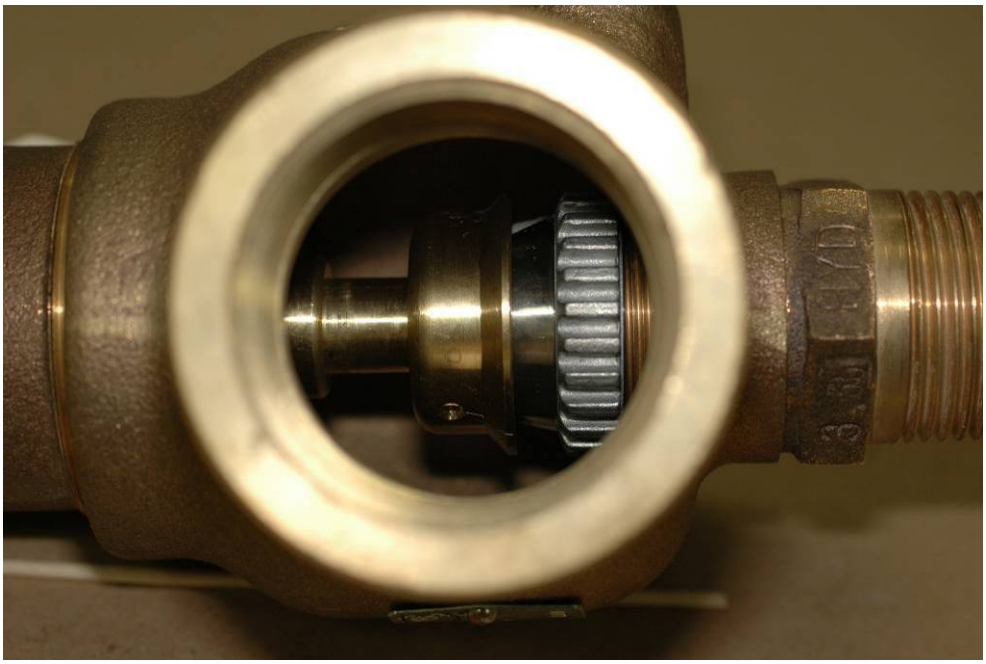


**Figure 43: Shows PRD identified as 08H127-Exemplar**

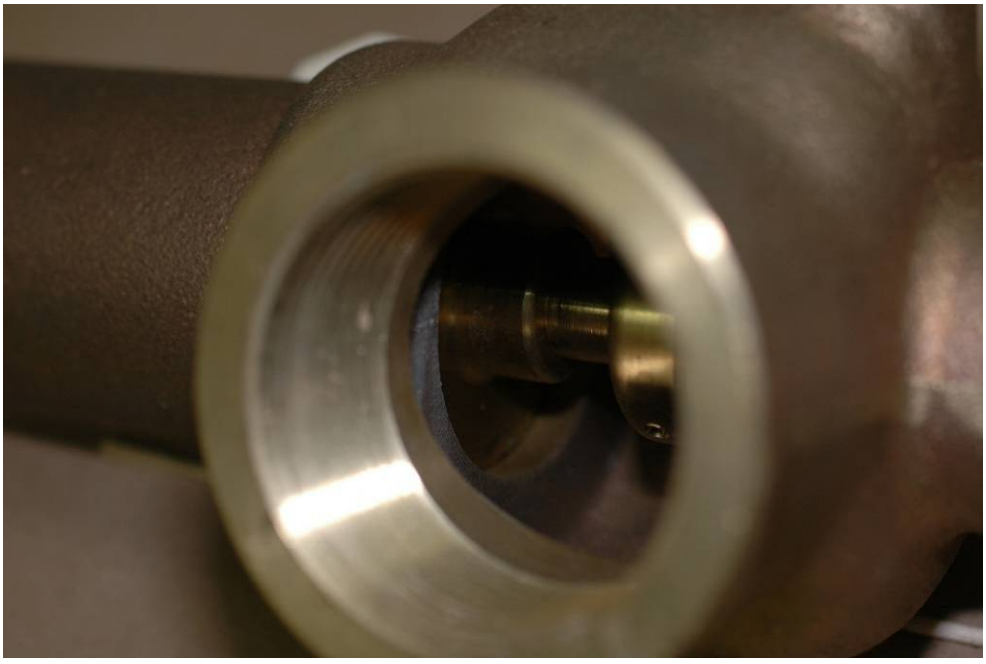


**Figure 44: Shows PRD identified as 08H127-Exemplar**


**Figure 45: Shows PRD identified as 08H127-Exemplar**


**Figure 46: Shows PRD identified as 08H127-Exemplar**


**Figure 47: Shows PRD identified as 08H127-Exemplar**


**Figure 48: Shows PRD identified as 08H127-Exemplar**

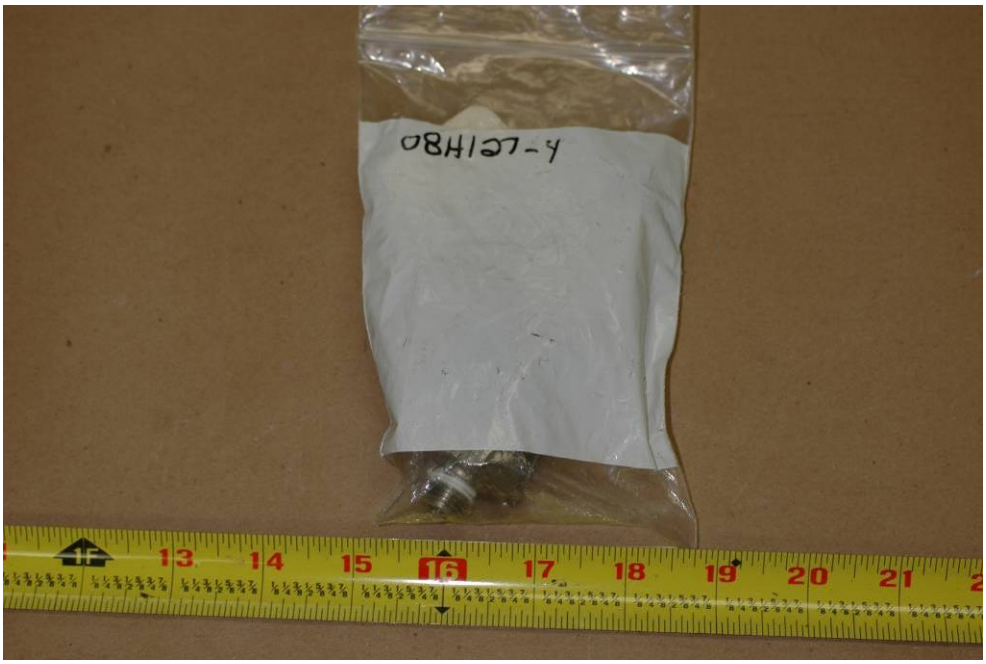



**Figure 49: Shows the as received PRD identified as 08H127-4**

**Figure 50: Shows the as received PRD identified as 08H127-4**


**Figure 51: Shows PRD identified as 08H127-4**


**Figure 52: Shows PRD identified as 08H127-4**

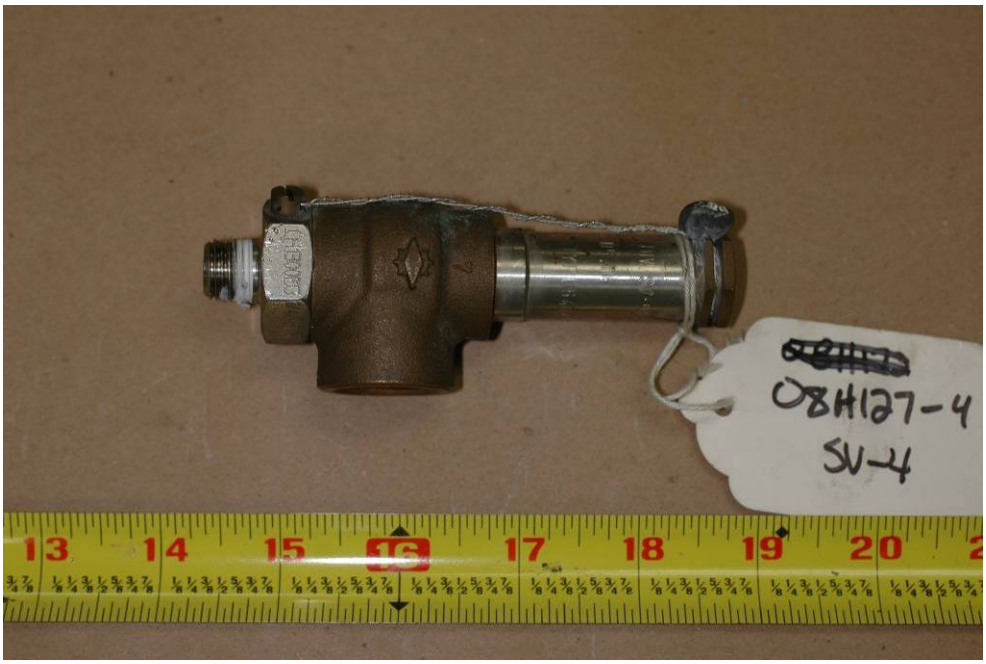



**Figure 53: Shows PRD identified as 08H127-4**

**Figure 54: Shows PRD identified as 08H127-4**


**Figure 55: Shows PRD identified as 08H127-4**


**Figure 56: Shows PRD identified as 08H127-4**

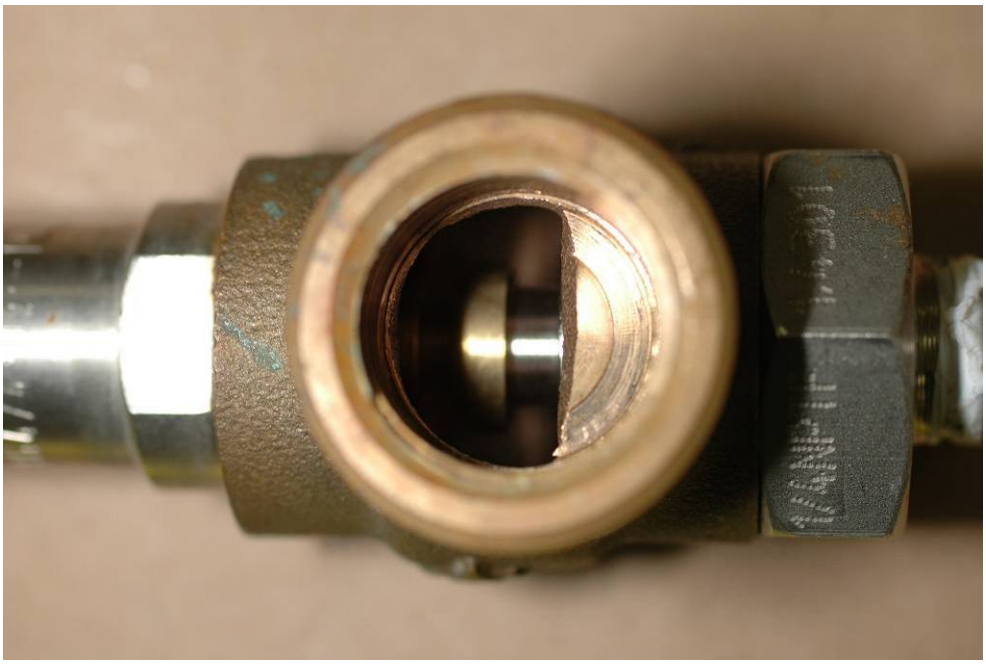


**Figure 57: Shows PRD identified as 08H127-4**


**Figure 58: Shows PRD identified as 08H127-4**

**Figure 59: Shows PRD identified as 08H127-4**

**Figure 60: Shows PRD identified as 08H127-4**


**Figure 61: Shows PRD identified as 08H127-4**

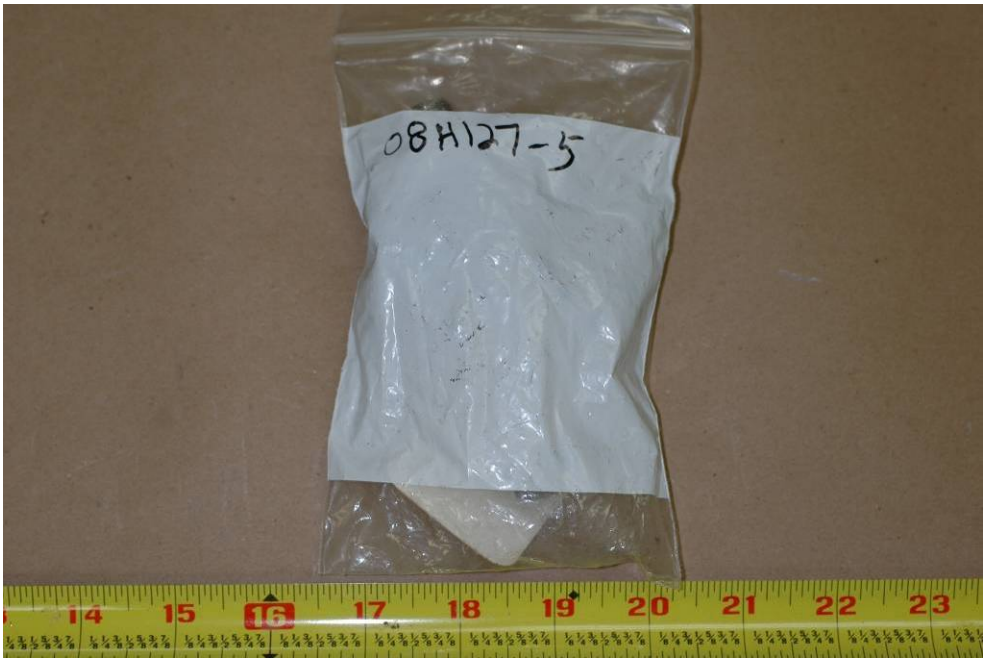



**Figure 62: Shows the as received PRD identified as 08H127-5**


**Figure 63: Shows the as received PRD identified as 08H127-5**


**Figure 64: Shows PRD identified as 08H127-5**


**Figure 65: Shows PRD identified as 08H127-5**


**Figure 66: Shows PRD identified as 08H127-5**

**Figure 67: Shows PRD identified as 08H127-5**

**Figure 68: Shows PRD identified as 08H127-5**

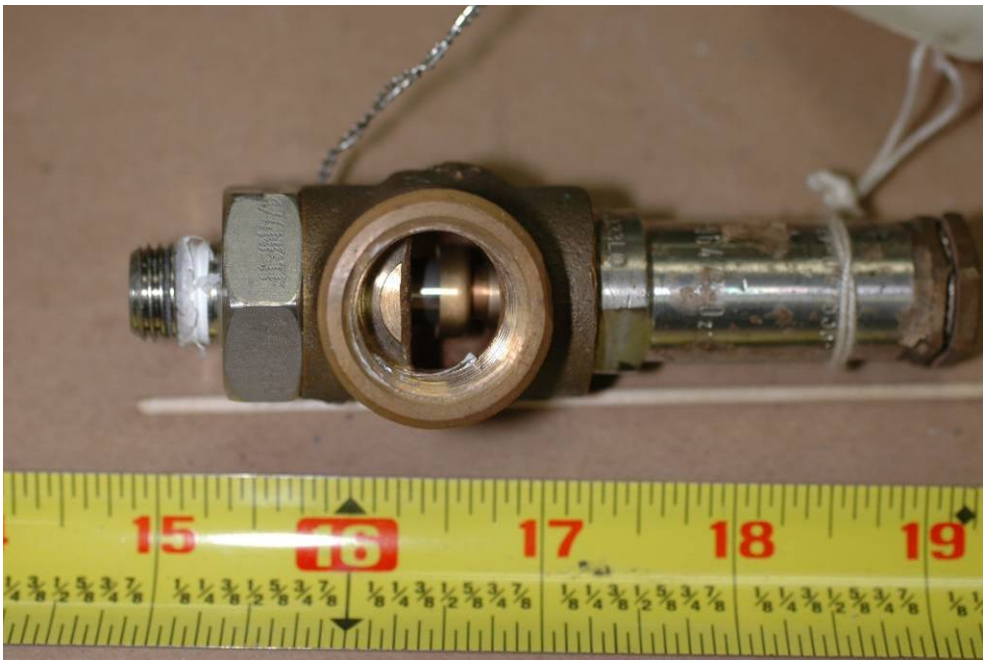



**Figure 69: Shows PRD identified as 08H127-5**

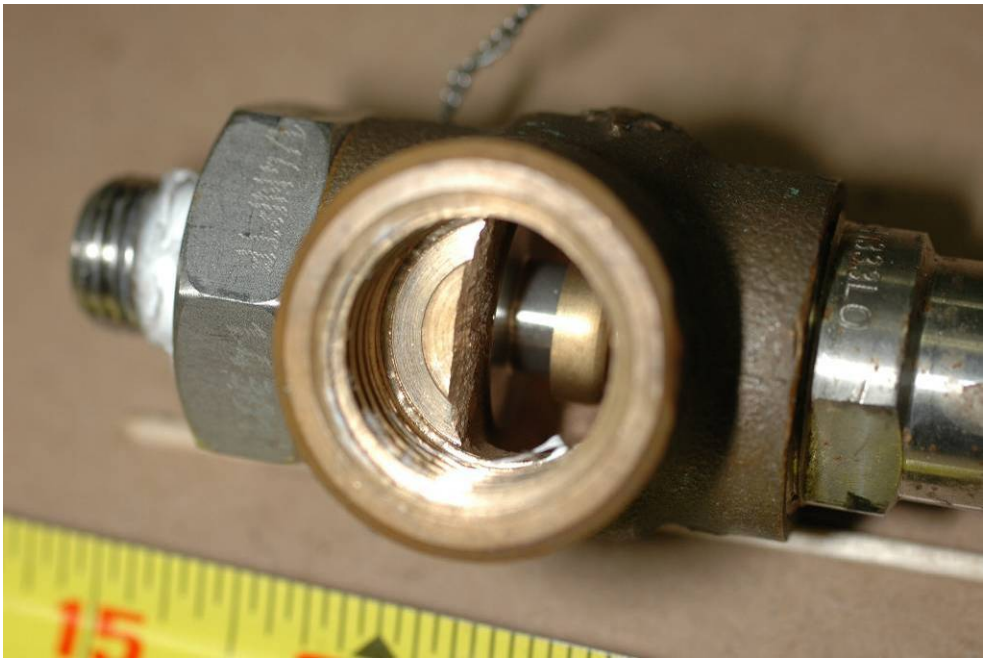


**Figure 70: Shows PRD identified as 08H127-5**

**Figure 71: Shows PRD identified as 08H127-5**


**Figure 72: Shows PRD identified as 08H127-5**

**Figure 73: Shows PRD identified as 08H127-5**



# Appendix A
# PRD Data Sheets

**Kunkle Safety and Relief Products**
**Model 900**

## Models 912, 913, 918 and 919 ASME Section VIII, Air/Steam/Gas/Liquid, "UV" National Board Certified. Also available for Vacuum Service. PED Certified for Non-Hazardous Gas.


### Features

- Available with soft seat.
- Threaded cap is standard (back pressure tight).
- Hex on valve nozzle provides for easy installation.
- Warn ring offers easy adjustability.
- Pivoting disc design corrects misalignment and offers exceptional performance.
- Guide to nozzle ratio reduces friction.
- Full nozzle design for optimum flow performance.
- Threaded side outlet for piped off discharge to eliminate fugitive emissions.

### Model Descriptions

**Model 912:** Full nozzle design. Stainless Steel (SS) warn ring and disc with brass/bronze base. Bronze/brass body and bonnet.

**Model 913:** Full nozzle design. Bronze/brass body and bonnet. 316 SS trim (base, disc and disc holder).

**Model 918:** Same as model 912 except resilient seat/seal. Superior "leak-free" performance. FM approved with 316 SS base for fire pump installations in "BDD" and "BDE" sizes[2].

**Model 919:** Same as model 913 except resilient seat/seal. Superior "leak-free" performance. Bronze body and bonnet. 316 SS trim (base, disc and disc holder).

### Applications

- Air/gas compressors - intercoolers - aftercoolers.
- Liquid filled pressure vessels/systems - ASME Section VIII (UV).
- Pressure vessels - containing gas, air, liquid or steam. Including tanks and receivers.
- Vacuum systems including pumps, tanks and equipment.
- Optional materials for low temperature - cryogenic applications.
- Oil/gas separators.
- Overpressure relief and protection of pumps, tanks, lines and hydraulic systems.
- By-pass relief or pressure regulation.

### Options

- Threaded cap. (variation 01)
- Threaded cap with gag. (variation 02)
- Plain lever. (variation 03)
- Plain lever with gag. (variation 04)
- Plain lever with vibration dampener. (variation 05)
- Packed lever. (variation 06)
- Packed lever with gag. (variation 07)

### Pressure and Temperature Limits

**Models 912, 918:** – Steam
3 to 250 psig [0.2 to 17.2 barg][1]
-320° to 406°F [-195° to 208°C]

**Models 913, 919:** – Steam
3 to 300 psig [0.2 to 20.7 barg][1]
-320° to 425°F [-195° to 219°C]

**Models 912, 918:** – Air/Gas/Liquid
3 to 300 psig [0.2 to 20.7 barg]
-320° to 406°F [-195° to 208°C]

**Models 913, 919:** – Air/Gas/Liquid
3 to 1400 psig [0.2 to 96.5 barg]
-320° to 425°F [-195° to 219°C]

Vacuum – 6" to 29" HG
[200 to 1000 mbarg] – 300°F [149°C]

Maximum back pressure 50 psig [3 barg] - threaded cap and packed lever[3]

**Notes**

1. ASME standard valves for air or steam service must have lift lever. For steam boilers and generators.
2. Requires Variation 08 for specific set pressure or variations listed below for adjustable relief pressure settings:
   Variation 10: 60 - 125 psig [4.1 - 8.6 barg],
   Variation 11: 125 - 175 psig [8.7 - 12 barg], or
   Variation 12: 176 - 250 psig [12.1 - 17.2 barg]
3. Back pressure increases set pressure on a one to one basis, and reduces capacity. Back pressure in excess of 10% of set pressure is not recommended.

**Kunkle Safety and Relief Products**
Model 900

## Specifications - Models 912, 913, 918, and 919

**Models 912, 913, 918, 919 ASME Section VIII, Steam/Air/Gas/ Liquid, "UV" National Board Certified. Also available for Vacuum Service**

### Service Recommendations for Resilient Seat/Seal Materials

| Seat/Seal Materials[1] | Service Recommendation |
|---|---|
| BUNA-N (-40° to 275°F) [-40° to 135°C] | Air, Anhydrous Ammonia, Butane, Carbon Dioxide, Diesel Oil, Ethyl Chloride, Ethyl Ether, Freons #11 and 12, Fuel Oil, Gasoline, Helium, Hydrogen Sulphide, Kerosene, Lube Oil, Natural Gas, Nitrogen, Oxygen (Gas), Propane, Propylene, Sulphur Dioxide, Vinyl Chloride |
| Viton® A (-15° to 406°F) [-26° to 208°C] | Acetone, Air, Amyl Alcohol, Aniline, Benzine, Butane, Carbon Disulphide, Carbon Tetrachloride Dowtherm "A" and "E," Ethyl Chloride, Ethylene, Ethylene Glycol, Ethyl Alcohol, Gasoline, Hexane, Hydrogen Sulphide, Isobutyl Alcohol, JP - 4 Fuel, JP - 5 Fuel, Kerosene, Lube Oil, Natural Gas, Naphtha, Nitrogen, Propane, Propylene, Propyl Alcohol, Sulphur Dioxide, Toluene, Trichloroethylene, Turpentine, Water, Xylene |
| Silicone (-100° to 406°F) [-73° to 208°C] | Air, Helium, Nitrogen, Oxygen (Gas) |
| Ethylene Propylene (-70° to 400°F) [-57° to 205°C] | Steam, Hot Water |
| Neoprene (-45° to 300°F) [-43° to 149°C] | Air, Anhydrous Ammonia, Butane, Butyl Alcohol, Castor Oil Denatured Alcohol, Ethanol, Ethyl Alcohol, Freons (12, 13, 14 and 22), Glycols, Natural Gas and Silicate Esters |

**Note**

1. These recommendations are a guide only. For the final selection of the proper material, your experience with available elastomers of various lading fluids should be considered.

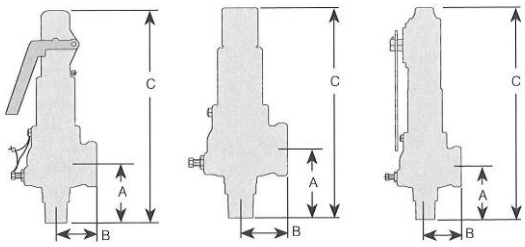
### Specifications

| Model[2] Number | Orifice | Connections ANSI Standard Inlet | Outlet | Maximum Set Pressure psig [barg] 912-918[4] | 913-919[5] | Dimensions, in [mm] A | B | C Plain Lever | C Threaded Cap | C Packed Lever | Approx. Weight lb [kg] |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 9*BDC | D | 1/2" [12.7] | 3/4" [19.0] | 300 [20.7] | 1400 [96.5] | 2 3/8 [60] | 1 5/8 [41] | 8 3/8 [213] | 7 1/4 [184] | 9 [229] | 3 [1.4] |
| 9*BDC[7] | D | 1/2" [12.7] | 1" [25.4] | 300 [20.7] | 1400 [96.5] | 2 3/8 [60] | 1 5/8 [41] | 8 3/8 [213] | 7 1/4 [184] | 9 [229] | 3 [1.4] |
| 9*BDD[3] | D | 3/4" [19.0] | 3/4" [19.0] | — — | 1400 [96.5] | 2 3/8 [60] | 1 5/8 [41] | 8 3/8 [213] | 7 1/4 [184] | 9 [229] | 3 [1.4] |
| 9*BDD[3,8] | D | 3/4" [19.0] | 1" [25.4] | — — | 1400 [96.5] | 2 3/8 [60] | 1 5/8 [41] | 8 3/8 [213] | 7 1/4 [184] | 9 [229] | 3 [1.4] |
| 9*BDE[3] | D | 1" [25.4] | 1" [25.4] | — — | 1400 [96.5] | 2 5/8 [67] | 1 5/8 [41] | 8 5/8 [219] | 7 1/2 [191] | 9 1/8 [232] | 3 [1.4] |
| 9*BED[9] | E | 3/4" [19.0] | 1 1/4" [31.8] | 300 [20.7] | 1000 [68.9][9] | 2 5/8 [67] | 2 [51] | 8 3/4 [222] | 7 5/8 [194] | 9 3/8 [238] | 4 [1.8] |
| 9*BEF[3] | E | 1 1/4" [31.8] | 1 1/4" [31.8] | — — | 1000 [68.9][9] | 3 [76] | 2 [51] | 9 1/8 [232] | 8 [203] | 9 3/4 [248] | 4 [1.8] |
| 9*BFE | F | 1" [25.4] | 1 1/2" [38.1] | 300 [20.7] | 700 [48.3][10] | 2 7/8 [73] | 2 3/8 [60] | 9 7/8 [251] | 8 3/4 [222] | 10 1/2 [267] | 6 [2.7] |
| 9*BFG[3] | F | 1 1/2" [38.1] | 1 1/2" [38.1] | — — | 700 [48.3][10] | 3 [76] | 2 3/8 [60] | 10 [254] | 8 7/8 [225] | 10 5/8 [270] | 6 [2.7] |
| 9*BGF | G | 1 1/4" [31.8] | 2" [50.8] | 300 [20.7] | 600 [41.4] | 3 1/4 [83] | 2 5/8 [67] | 11 1/4 [286] | 10 1/8 [257] | 11 3/4 [298] | 8 [3.6] |
| 9*BGH[3] | G | 2" [50.8] | 2" [50.8] | — — | 600 [41.4] | 3 1/4 [83] | 2 5/8 [67] | 11 1/4 [286] | 10 1/8 [257] | 11 3/4 [298] | 8 [3.6] |
| 9*BHG | H | 1 1/2" [38.1] | 2 1/2" [63.5] | 300 [20.7] | 500 [34.5] | 3 1/2 [89] | 2 3/4 [70] | 13 [330] | 11 1/8 [283] | 12 1/2 [318] | 11 [5.0] |
| 9*BJH | J[6] | 2" [50.8] | 3" [76.2] | 300 [20.7] | 500 [34.5][11] | 4 [102] | 3 1/4 [83] | 14 1/2 [368] | 12 1/2 [318] | 15 1/8 [384] | 15 [6.8] |

Dimensions are for reference only.

**Notes**

1. Maximum temperature controlled by resilient seat/seal material.
2. Replace asterisk with desired Model Number. Data applicable to all models.
3. Available with SS trim (models 913 and 919) only.
4. Maximum pressure on steam is 250 psig.
5. Maximum pressure on steam is 300 psig.
6. For C dimensions: pressures above 200 psig [14 barg] add 1.25" [31.8 mm] to the overall height.
7. Special variation required (12 - Threaded Cap, 14 - Plain Lever, 17 - Packed Lever).
8. Special variation required (13 - Threaded Cap, 14 - Plain Lever, 17 - Packed Lever).
9. 900 psig for liquid service or high temp alloy spring.
10. 600 psig for liquid service or high temp alloy spring.
11. 367 [25.3] for plain lever with gag.




Plain Lever | Threaded Cap | Packed Lever

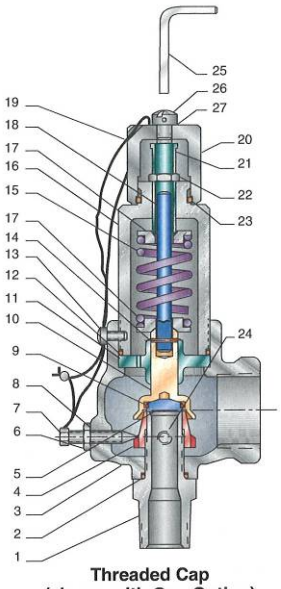
## Kunkle Safety and Relief Products
Model 900

### Specifications - Models 912, 913, 918, and 919

**Models 912, 913, 918, 919 ASME Section VIII, Steam/Air/Gas/ Liquid, "UV" National Board Certified. Also available for Vacuum Service**

#### Parts and Materials - Models 912, 913, 918, 919 Threaded Cap

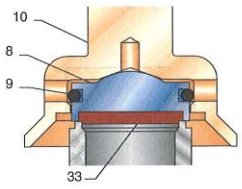
| No. | Part Name | Materials |
|---|---|---|
| 1 | Nozzle[2] | Brass, B21 or B283 Alloy 485, (SS, SA351-CF8M[5] Models 913, 919 only) |
| 2 | O-ring Body[6] | Teflon® |
| 3 | Body | Bronze, B584 Alloy 84400 |
| 4 | Warn Ring | SS, A743-CF8M |
| 5 | Disc[1] | SS, A479-316 |
| 6 | Set Screw Nut | SS 18-8 |
| 7 | Set Screw | Brass, B16 |
| 8 | Seal | Teflon® |
| 9 | Retainer Ring | SS, A313-316 |
| 10 | Disc Holder | Brass, B16, (SS A351-CF8M Models 913, 919 only) |
| 11 | Guide[3]<br>Guide Lock Nut[7]<br>Shield[7] | Brass, B16<br>Brass, B16<br>SS, A167-316 |
| 12 | Bonnet O-ring[6] | Teflon® |
| 13 | Screw | SS, Commercial 18-8 |
| 14 | Coiled Spring Pin | SS, A313-302 |
| 15 | Spring | SS: A313-316 or A313-T631/Alloy steel: A681-H12 or B637-X750 |
| 16 | Bonnet[4] | Brass, B16-H02 |
| 17 | Spring Step | Brass, B16 |
| 18 | Stem | Brass, B16 |
| 19 | Wire and Seal | SS wire and lead seal, Commercial |
| 20 | Cap | Brass, B16 |
| 21 | Compression Screw | Brass, B16 |
| 22 | Jam Nut | SS 18-8 or Brass, B16 |
| 23 | Cap O-ring | BUNA-N |
| 24 | Body Plug | Brass, B16 [1/4" - 18 NPT] |
| 25[8] | Gag Screw | Steel A108-1018/Zinc Plated |
| 26[9] | Gag Screw Plug | SS 18-8 |
| 27[9] | Gag Screw Gasket | Teflon® |




**Threaded Cap (shown with Gag Option)**

#### Parts and Materials - Models 918 and 919 Soft Seat, F to J Orifice

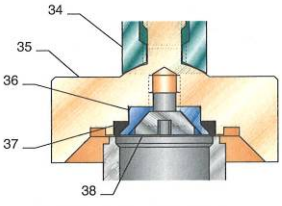
| No. | Part Name | 918 | 919 |
|---|---|---|---|
| 8 | Disc | SS A479-316 | SS A479-316 |
| 9 | Ring, Retainer | SS A313-316 | SS A313-316 |
| 10 | Disc Holder | Brass, B16 | SS A351-CF8M |
| 33 | Molded Seat[1] | | |




**Soft Seat F to J Orifice**

#### Parts and Materials - Models 918 and 919 Soft Seat, D and E Orifice

| No. | Part Name | 918 | 919 |
|---|---|---|---|
| 34 | Spindle | Brass, B16 | SS A479-316 |
| 35 | Disc Holder | Brass, B16 | SS A479-316 |
| 36 | Retainer | Brass, B16 | SS A479-316 |
| 37 | O-ring Seat[1] | | |
| 38 | Seat Retainer Screw | SS 18-8 | SS 18-8 |



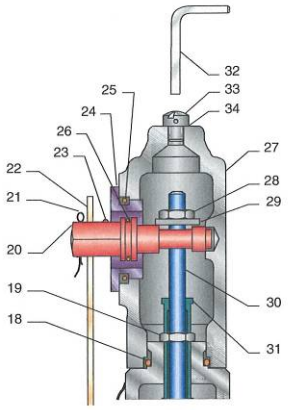

**Soft Seat D and E Orifice**

#### Notes

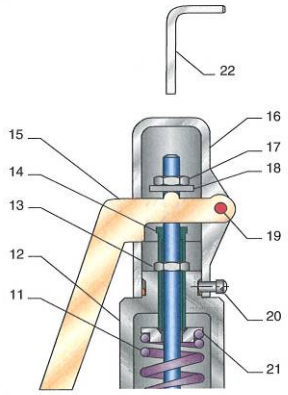
1. Material — Letter Designation
   - BUNA-N - B
   - Ethylene Propylene (EPR/EPDM) - E
   - Neoprene - N
   - Silicone - S
   - Viton® - V
2. F through J orifice nozzle material is Bronze, B62.
3. G through J orifice guide material is Bronze, B584, Alloy 84400.
4. F through J orifice bonnet material is Bronze, B584, Alloy 84400.
5. "D" and "E" orifice, 9*BFG, and 9*BGH nozzle material is SS, SA479-316.
6. For threaded cap and packed lever only.
7. For "J" orifice only (not shown).
8. Gag screw ships with valve, not installed.
9. For threaded cap and packed lever gag option only.

**Kunkle Safety and Relief Products**
Model 900

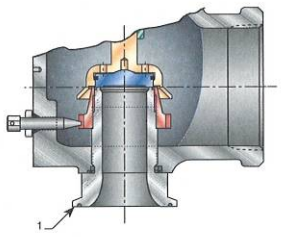
## Specifications - Models 912, 913, 918, and 919




**Packed Lever (shown with Gag Option)**




**Plain Lever (shown with Gag Option)**




**Tri-Clover (Inlet only)**

**Models 912, 913, 918, 919 ASME Section VIII, Steam/Air/Gas/Liquid, "UV" National Board Certified. Also available for Vacuum Service**

### Parts and Materials - Model 912 Packed Lever

| No. | Part Name | Materials |
|---|---|---|
| 18 | Cap O-ring | BUNA-N 70 Duro, Commercial |
| 19 | Jam Nut | Brass, B16 |
| 20 | Lift Cam | SS, A743 CF8M |
| 21 | Cotter Pin | Steel, Commercial |
| 22 | Lever | Zinc Plated Steel, A108 |
| 23 | Drive Screw | SS, Commercial |
| 24 | Retainer Nut | Brass, B16 |
| 25 | Retainer O-ring | BUNA-N 70 Duro, Commercial |
| 26 | Lift Cam O-ring | BUNA-N 70 Duro, Commercial |
| 27 | Cap | Bronze, B584 Alloy 84400 |
| 28 | Lift Nut | SS, A479 316 |
| 29 | Lift Washer | SS, A479 316 |
| 30 | Stem | Brass, B16 |
| 31 | Compression Screw | Brass, B16 |
| 32[2] | Gag Screw | Steel A108-1018/Zinc Plated |
| 33[3] | Gag Screw Plug | SS 18-8 |
| 34[3] | Gag Screw Gasket | Teflon® |

### Parts and Materials - Model 912 Plain Lever

| No. | Part Name | Materials |
|---|---|---|
| 11 | Spring | Steel: A231/A231M w/coating[1]<br>SS: A313-302<br>SS: A313-316<br>Alloy steel: A681-H12 |
| 12 | Bonnet | Brass, B16 |
| 13 | Jam Nut | Brass, B16 |
| 14 | Compression Screw | Brass, B16 |
| 15 | Lever | Steel, A109 w/coating[1] |
| 16 | Cap | Aluminum, Anodized |
| 17 | Lift Nut | SS, A479-316 |
| 18 | Llft Washer | SS, A479-316 |
| 19 | Rivet | Steel, Commercial |
| 20 | Screw | SS, Commercial Gr. 18-8 |
| 21 | Spring Step | Brass, B16 |
| 22[2] | Gag Screw | Steel A108-1018/Zinc Plated |

### Model 911 - Available with Tri-Clover Adapter Inlet

| Model | Inlet | Orifice | Outlet |
|---|---|---|---|
| 911 ZDE | 1" | D | 1" |
| 911 ZEE | 1" | E | 1¼" |
| 911 ZFG | 1½" | F | 1½" |
| 911 ZGG | 1½" | G | 2" |
| 911 ZGH | 2" | G | 2" |
| 911 ZHH | 2" | H | 2½" |
| 911 ZJJ | 2½" | J | 3" |

### Notes

1. Corrosion preventative coating.
2. Gag screw ships with valve, not installed.
3. For threaded cap and packed lever gag option only.

## Kunkle Safety and Relief Products
Model 900

### Models 912, 913, 918, 919 ASME Section VIII, Steam/Air/Gas/ Liquid, "UV" National Board Certified. Also available for Vacuum Service

| Model Number Position | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Example | 9 | 1 | 2 | B | J | H | M | 0 | 1 | — | K | E | 0 | 3 | 0 | 0 |

**Model**
912, 913, 918, 919

**Connection Model**
B - Male x Female Threaded or NPT

**Orifice**
D, E, F, G, H, J

**Inlet Size**

| | | | |
|---|---|---|---|
| C - 1/2" | [15 mm] | F - 1 1/4" | [32 mm] |
| D - 3/4" | [18 mm] | G - 1 1/2" | [40 mm] |
| E - 1" | [25 mm] | H - 2" | [50 mm] |

**Seat/Seal Material**

| | |
|---|---|
| M - Metal-to-metal | S - Silicone |
| B - BUNA-N | V - Viton® |
| E - EPR | N - Neoprene |

**Variation (01 to 99)**
Number provided only by manufacturer to cover specific feature or option.
01 - Threaded cap
02 - Threaded cap with gag
03 - Plain lever
04 - Plain lever with gag
05 - Plain lever with vibration dampener
06 - Packed lever
07 - Packed lever with gag
12 - Threaded cap (9"BDC with 1" outlet)
13 - Threaded cap (9"BDD with 1" outlet)
14 - Plain lever - D orifice with 1" outlet
17 - Packed lever - D orifice with 1" outlet
60 - BSP threads with threaded cap

**Design Revision**

| | Orifice Size | | | | | |
|---|---|---|---|---|---|---|
| Models | D | E | F | G | H | J |
| 912 | – | – | – | – | – | – |
| 913 | – | – | – | – | – | – |
| 918 | B | B | – | – | – | – |
| 919 | B | B | – | – | – | – |

**Valve Service**
J - Liquid ASME Section VIII (Standard Cap/Packed Lever only)
K - Air/Gas ASME Section VIII (Plain Lever/Packed Lever required for air)
L - Steam ASME Section VIII (Plain Lever/Packed Lever required)
M - Non-Code Liquid (Standard Cap/Packed Lever only)
N - Non-Code Air Gas
P - Non-Code Steam
Q - Vacuum (Standard Cap/Packed Lever only)

**Spring Material**
E - SS
F - Alloy Steel (high temperature)

**Set Pressure**
3 psig [0.2 barg] (0003) to 900 psig [62 barg] (0900)
Vacuum 6" HG [200 mbarg] (0006) to 29" HG [1000 mbarg] (0029)

# Safety Valves
## Type 06474

HEROSE

**Cryogenic Safety Valves, angle type, bronze, PN63, type tested TÜV-SV. 836. S/G**

Standard safety valve,
with carbon filled PTFE valve seal, closed bonnet
Outlet: female thread G 1/2 acc. to ISO 228/1
" cleaned and degreased for oxygen service "

**Part No. 06474.X.0000**
Inlet: male thread type G (BSPP) acc. to ISO 228/1

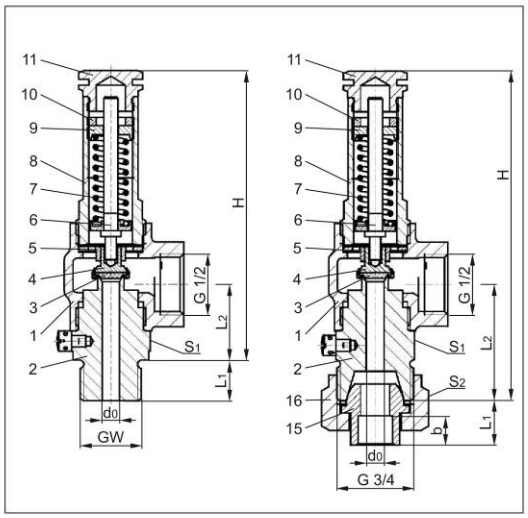
**Part No. 06474.X.5000**
Inlet: male thread NPT acc. to ANSI B 1.20.1

**Part No. 06474.0600.0000**
Inlet: union type braze fitting for pipe outside diameter 12 mm

Available options - on request only:
· external parts nickel plated
· with installed elbow at the outlet

**Applications:**
Provided as safety device for protection against excessive pressure in stationary and moveable gas cylinders.
Approved for air gases, vapours and cryogenic liquefied gases incl. LNG.
Working temperature: -196°C / -321°F (77K) up to +150°C / +302°F (423K)

| Materials | | DIN EN | ASTM |
|---|---|---|---|
| 1 | Outlet body | CC491K | B 62 UNS C83600 |
| 2 | Inlet body | 1.4301 | A 276 Grade 304 |
| 3 | Valve seal | PTFE / Carbon filled (25%) | |
| 4 | Disc | CW452K | B 103 UNS C51900 |
| 5 | Guide plate | CC493K | B 505 UNS C93200 |
| 6 | Stem | CW614N | B 283 UNS C38500 |
| 7 | Spring | 1.4571 | A 276 Grade 316Ti |
| 8 | Bonnet | 1.4305 | A 314 Grade 303 |
| 9 | Spring clamp | CW614N | B 283 UNS C38500 |
| 10 | Thread ring | CW614N | B 283 UNS C38500 |
| 11 | Cap | CW614N | B 283 UNS C38500 |
| 15 | Braze fitting | 1.4301 | A 276 Grade 304 |
| 16 | Union nut | CW614N | B 283 UNS C38500 |




**Essential:** Valves are delivered at a set pressure, therefore when ordering please confirm set pressure, medium and temperature.

Standard marking acc. to Pressure Equipment Directive 97/23/EC (PED). CE

Marking acc. to Directive 99/36/EG (TPED) will only be carried out by written notice on purchase order.

| Type 06474 | Technical data | | | | |
|---|---|---|---|---|---|
| **Nominal size** | **GW** | **1/4** | **3/8** | **1/2** | **3/4** |
| Orifice | $d_0$ | 6.0 | 6.0 | 6.0 | 6.0 |
| Dimension code | .X. | 0200 | 0300 | 0400 | - |
| Set pressure range | bar | 4.5-45.0 | 4.5-45.0 | 4.5-45.0 | 4.5-45.0 |
| Height | H | 100 | 100 | 100 | 114 |
| Length | $L_1$ | 12 | 13 | 14 | 14 |
| Length | $L_2$ | 26 | 26 | 26 | 40 |
| Socket depth | b | - | - | - | 8 |
| Wrench size across flats | $S_1$ | 27 | 27 | 27 | 27 |
| Wrench size across flats | $S_2$ | - | - | - | 32 |
| Weight | ca. kg | 0.34 | 0.36 | 0.38 | 0.47 |
| Coefficient of discharge | $\alpha_w$ | 0.66 | 0.66 | 0.66 | 0.66 |

Dimensions in mm.

## Safety Valves
## Type 06474

HEROSE

**Discharge capacities**

Calculation of mass flow acc. to AD2000-Merkblatt A2 / DIN EN ISO 4126-1

Medium:
**Air** in $m^3/h$ at 0°C and 1013.25 mbar

**The capacity indicated below is for a fully opened valve.**

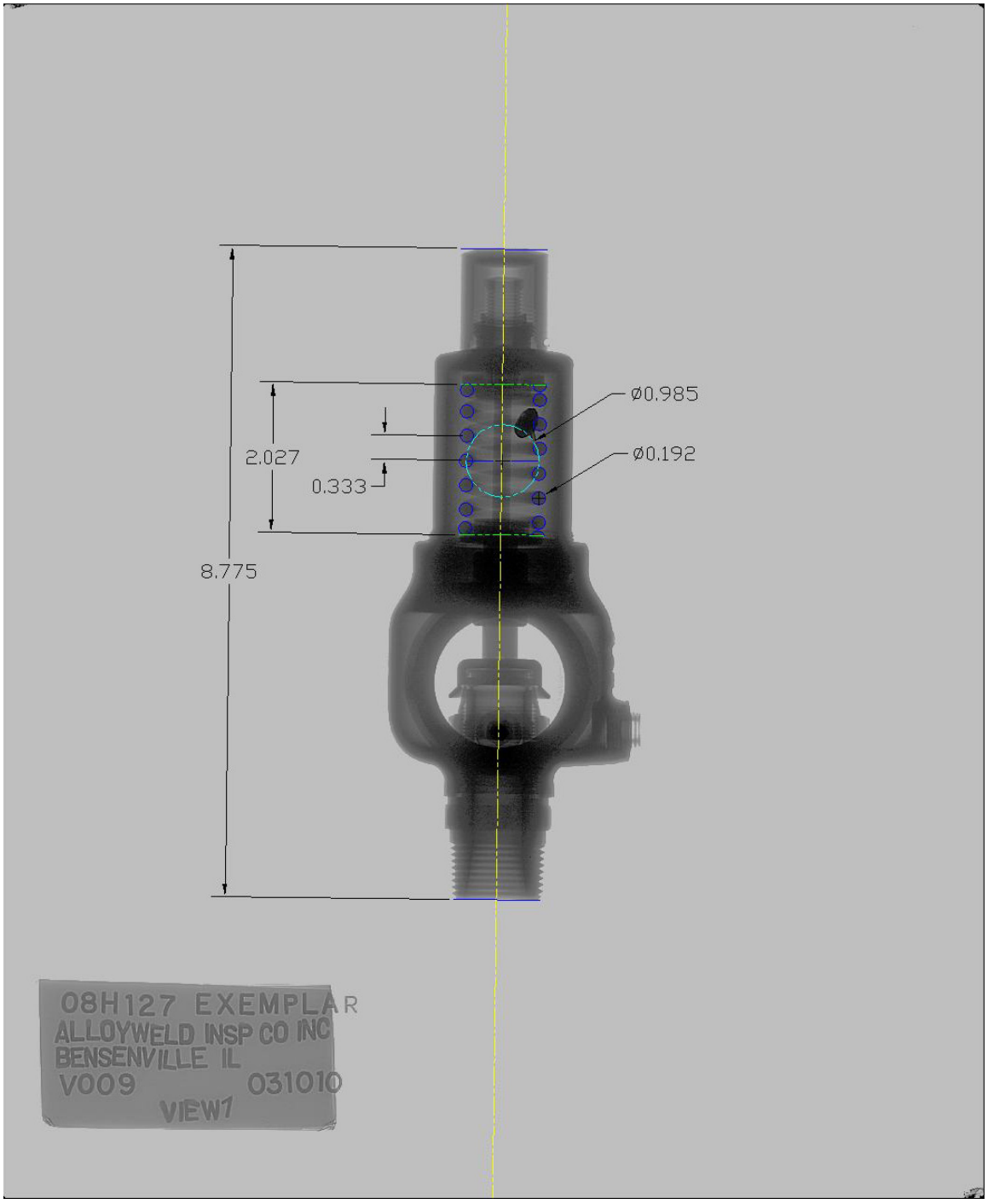
$d_0$ - orifice

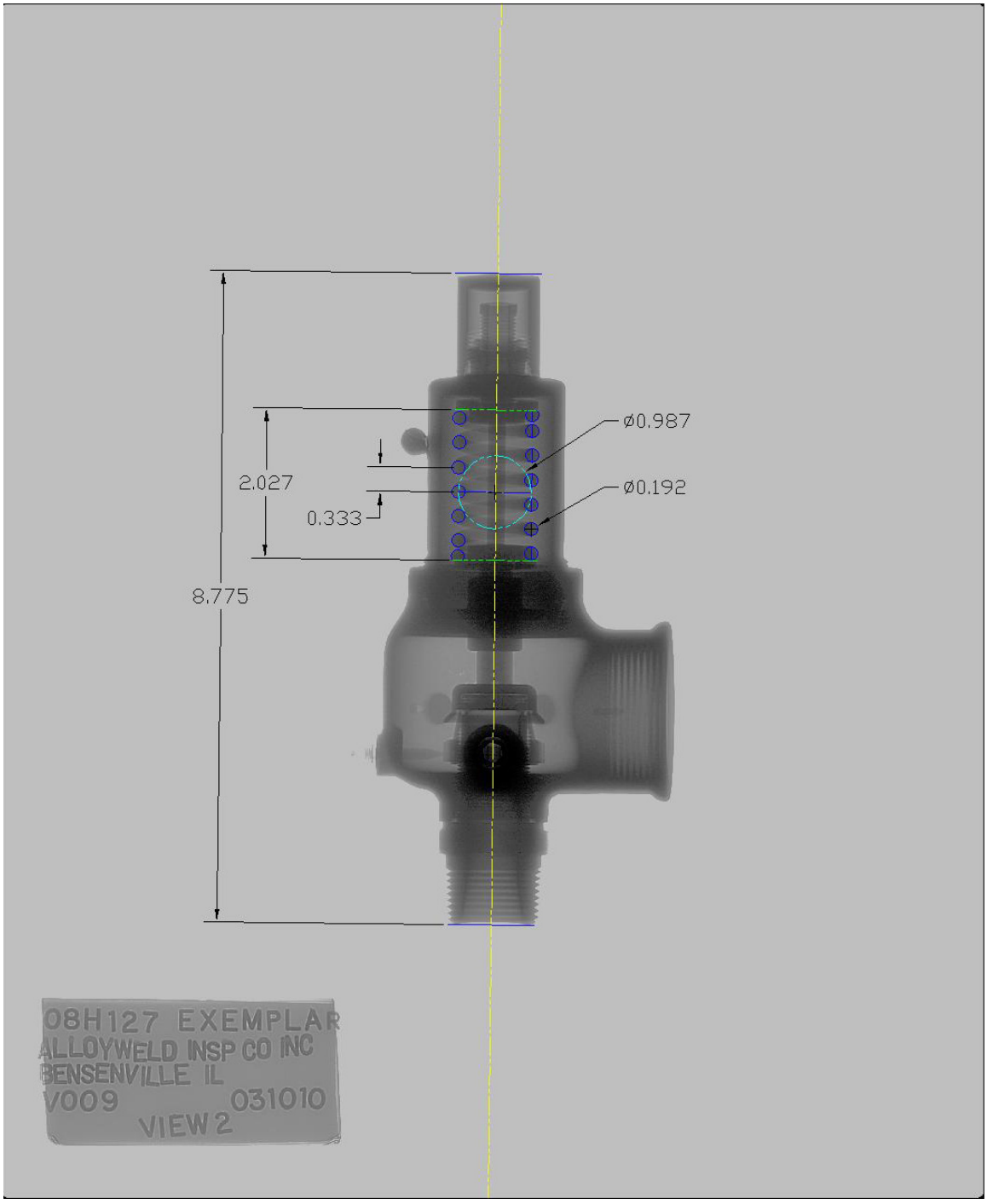
$A_0$ - flow area

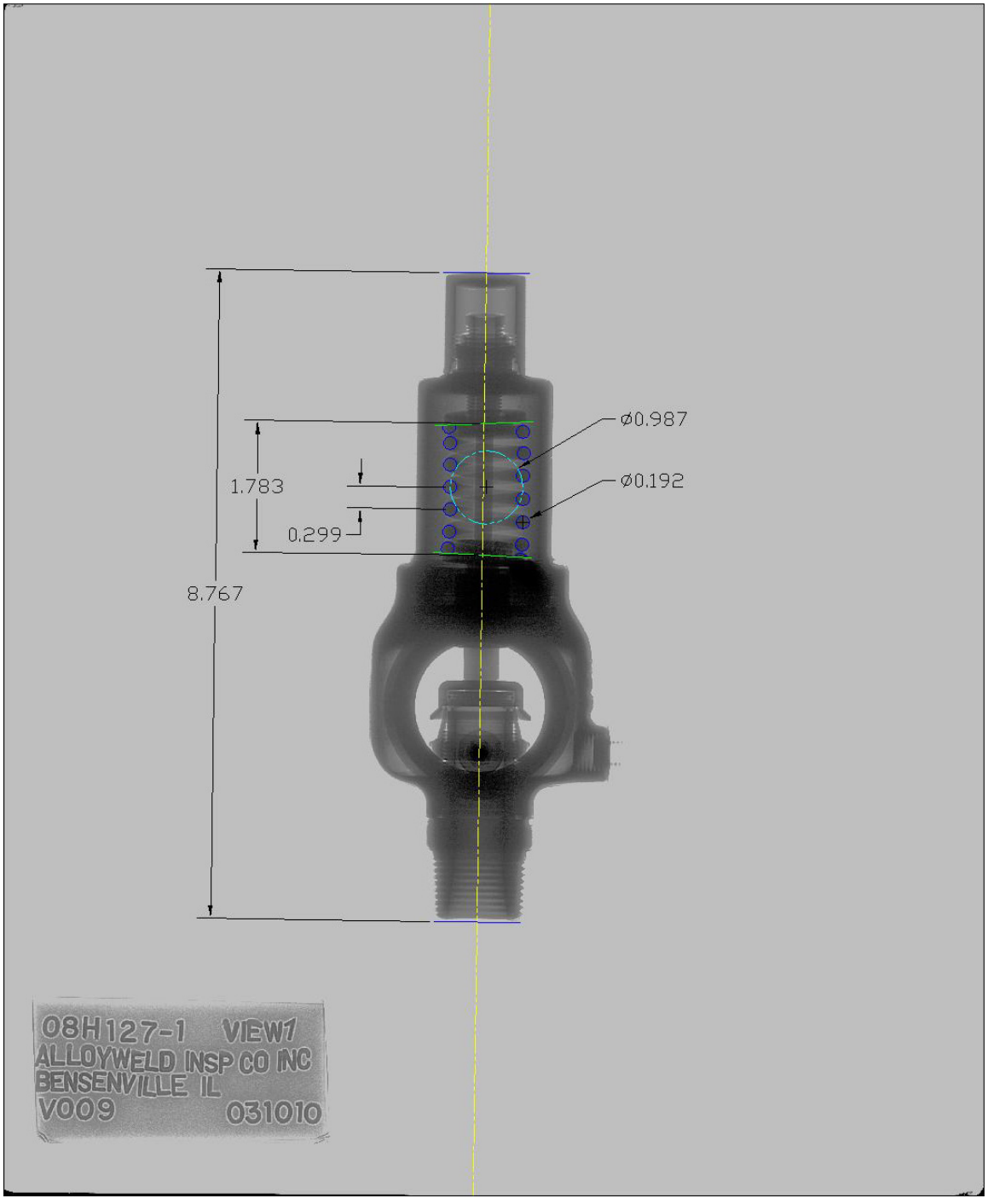
| Set pressure in bar (ü) | GW | 1/4 | 3/8 | 1/2 | 3/4 |
|---|---|---|---|---|---|
| | $d_0$ (mm) | 6.0 | 6.0 | 6.0 | 6.0 |
| | $A_0$ ($mm^2$) | 28.3 | 28.3 | 28.3 | 28.3 |
| | Medium | Air | | | |
| **4.5** | | 76 | 76 | 76 | 76 |
| **5.0** | | 83 | 83 | 83 | 83 |
| **6.0** | | 97 | 97 | 97 | 97 |
| **7.0** | | 111 | 111 | 111 | 111 |
| **8.0** | | 125 | 125 | 125 | 125 |
| **9.0** | | 139 | 139 | 139 | 139 |
| **10.0** | | 153 | 153 | 153 | 153 |
| **12.0** | | 181 | 181 | 181 | 181 |
| **14.0** | | 209 | 209 | 209 | 209 |
| **16.0** | | 237 | 237 | 237 | 237 |
| **18.0** | | 265 | 265 | 265 | 265 |
| **20.0** | | 293 | 293 | 293 | 293 |
| **22.0** | | 321 | 321 | 321 | 321 |
| **24.0** | | 349 | 349 | 349 | 349 |
| **26.0** | | 377 | 377 | 377 | 377 |
| **28.0** | | 404 | 404 | 404 | 404 |
| **30.0** | | 432 | 432 | 432 | 432 |
| **32.0** | | 460 | 460 | 460 | 460 |
| **34.0** | | 488 | 488 | 488 | 488 |
| **36.0** | | 516 | 516 | 516 | 516 |
| **38.0** | | 544 | 544 | 544 | 544 |
| **40.0** | | 572 | 572 | 572 | 572 |
| **42.0** | | 600 | 600 | 600 | 600 |
| **44.0** | | 628 | 628 | 628 | 628 |
| **45.0** | | 642 | 642 | 642 | 642 |

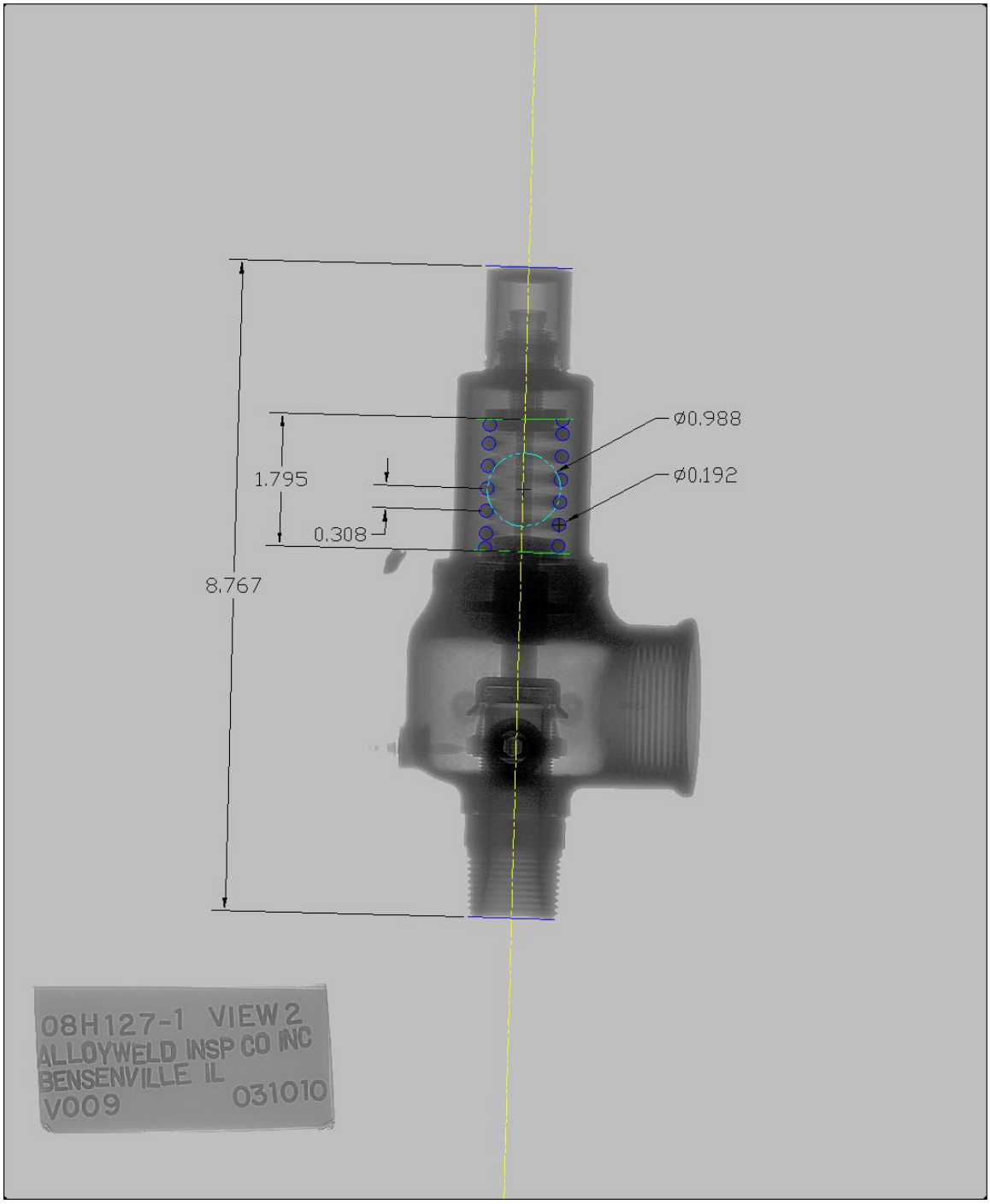


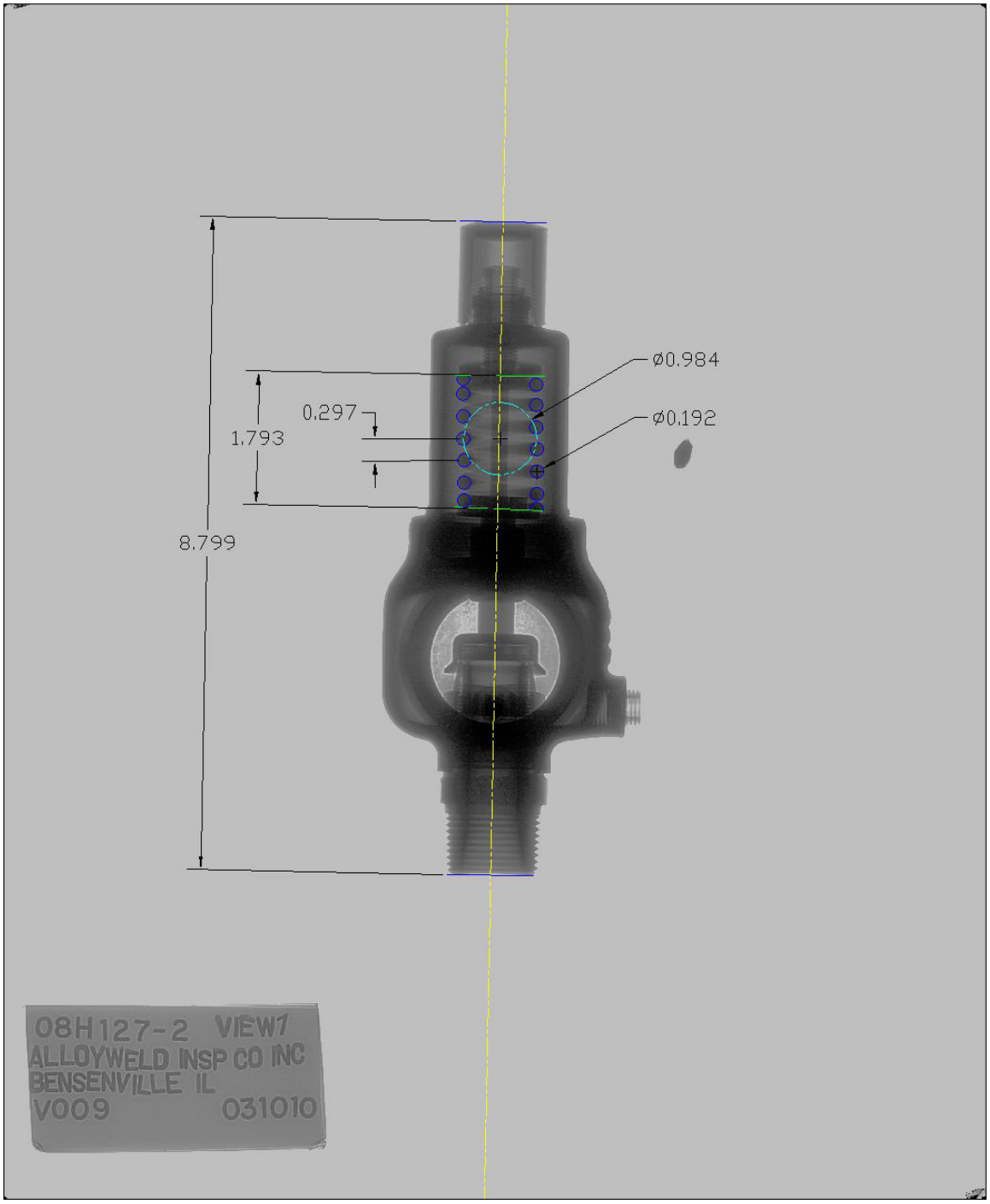
# Appendix B
# Radiographic Images

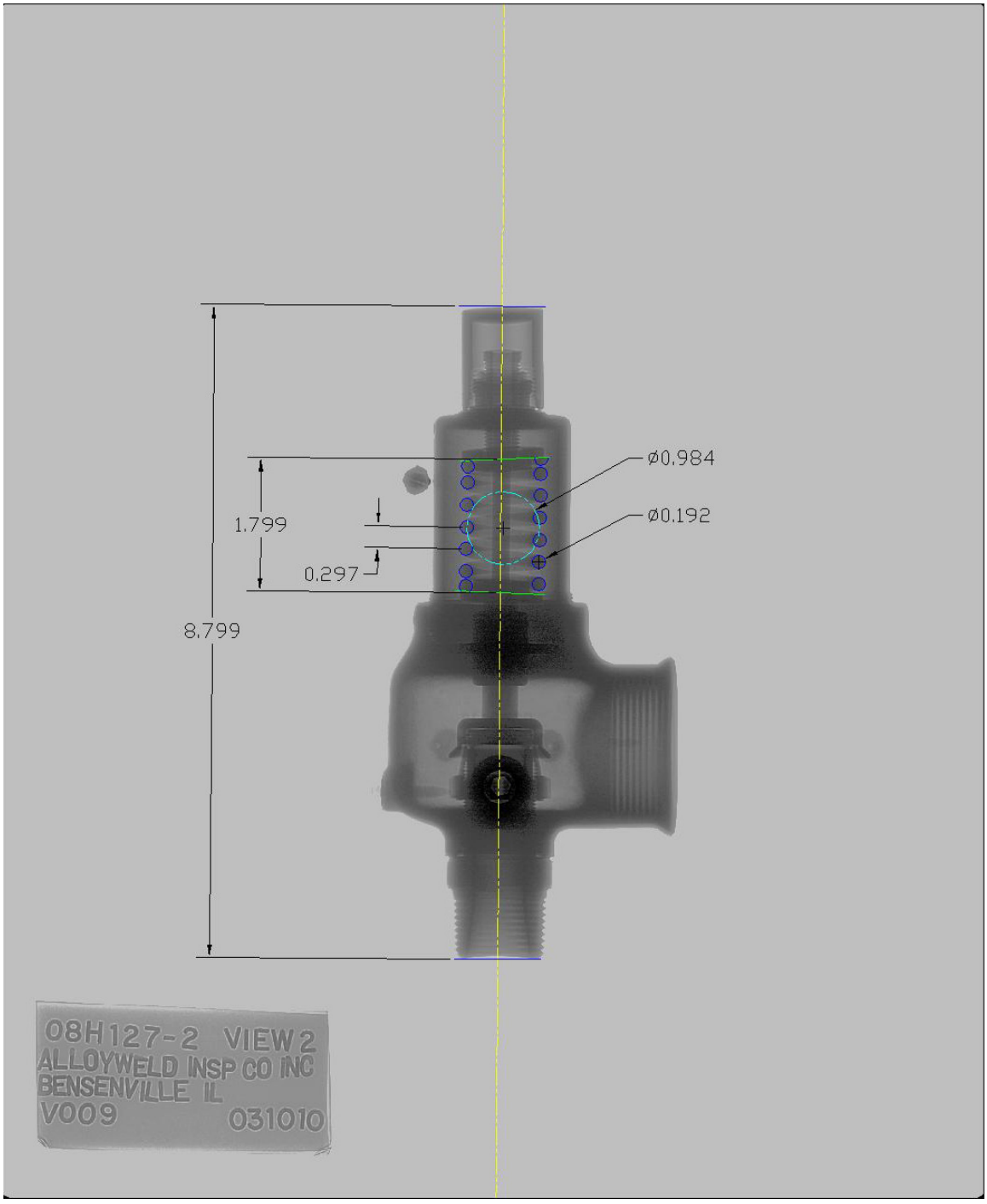

Ø0.985
Ø0.192
2.027
0.333
8.775
08H127 EXEMPLAR
ALLOYWELD INSP CO INC
BENSENVILLE IL
V009 031010
VIEW1

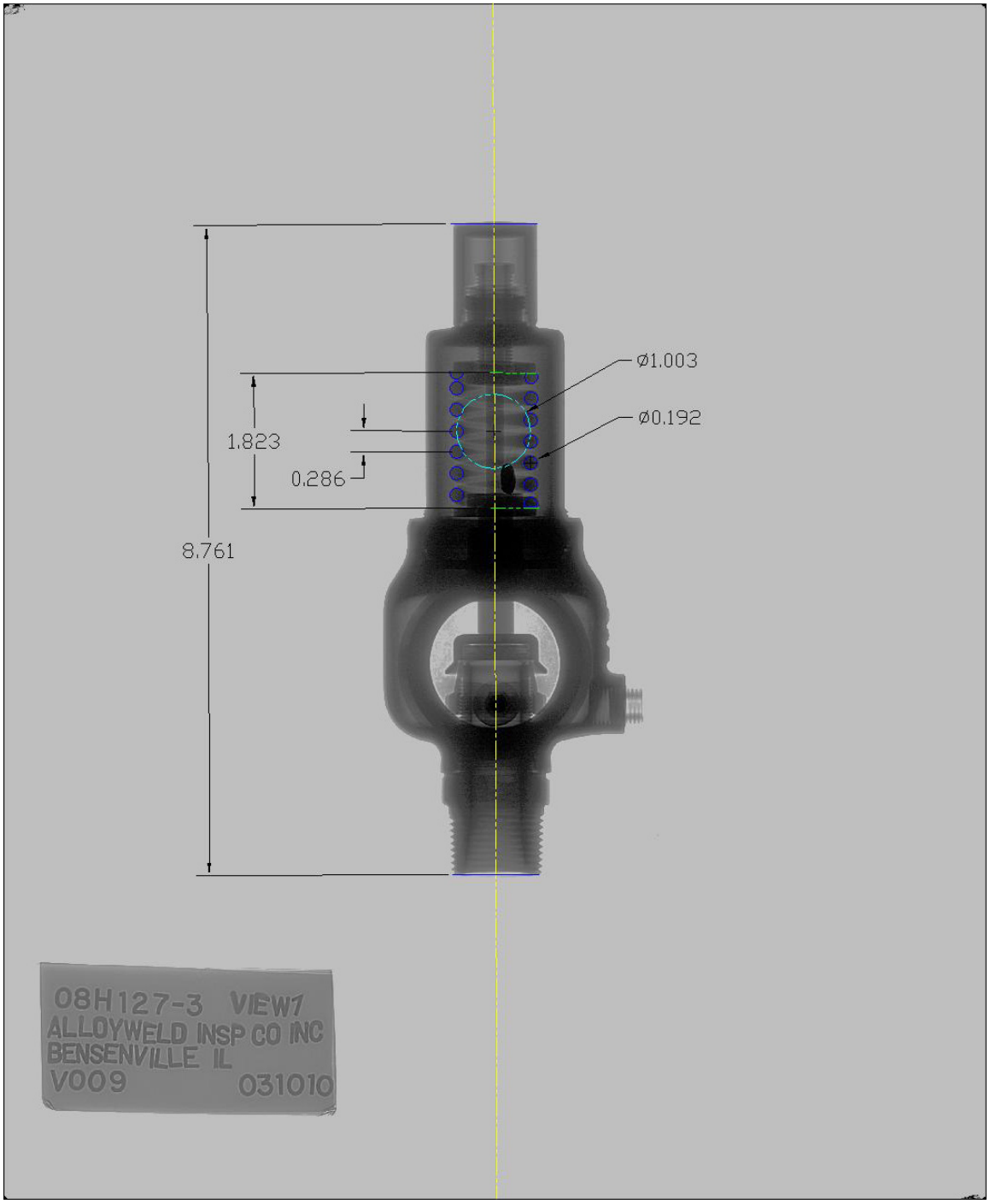

Ø0.987
Ø0.192
2.027
0.333
8.775
08H127 EXEMPLAR
ALLOYWELD INSP CO INC
BENSENVILLE IL
V009
031010
VIEW 2

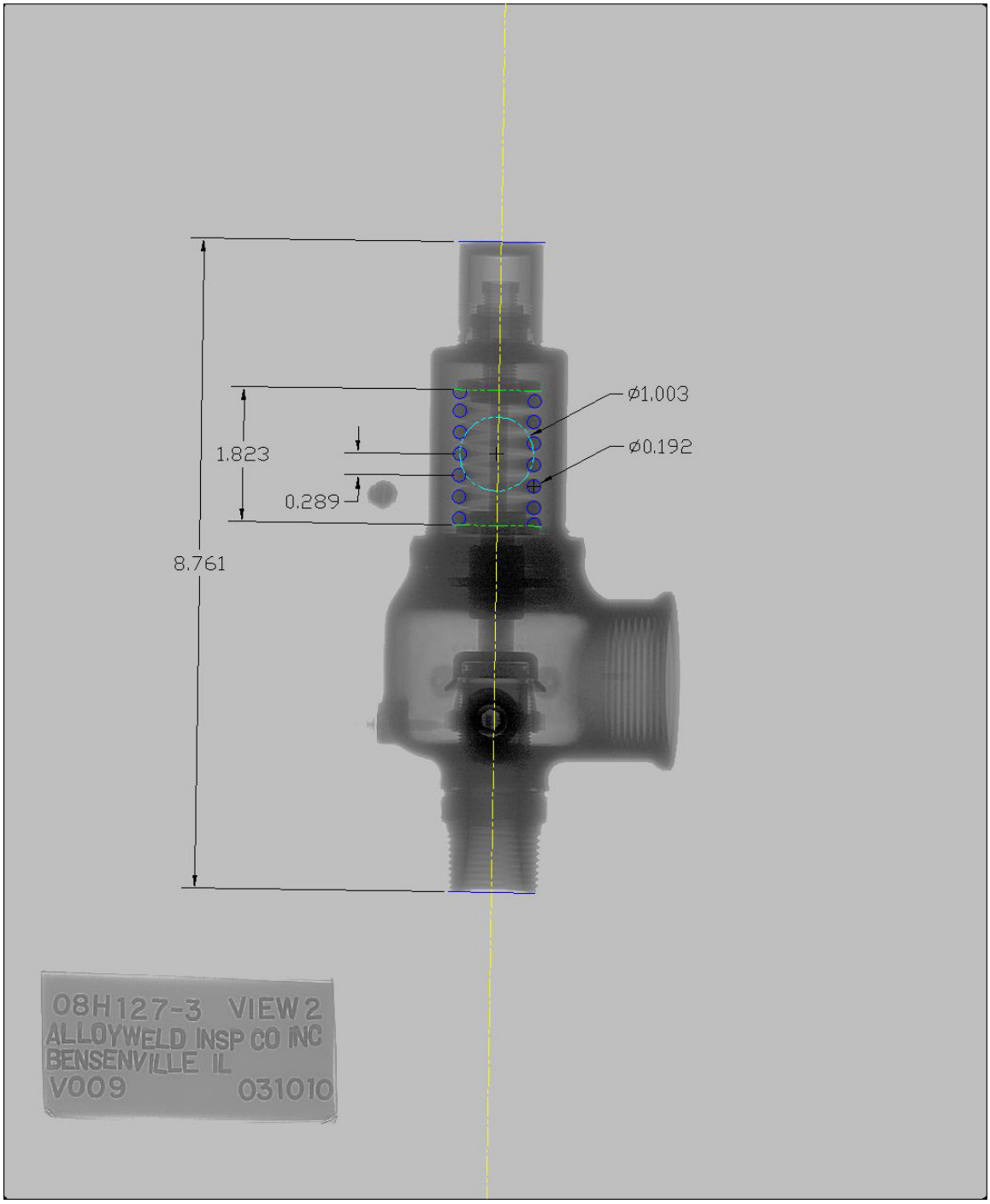

Ø0.987
Ø0.192
1.783
0.299
8.767
08H127-1 VIEW1
ALLOYWELD INSP CO INC
BENSENVILLE IL
V009 031010

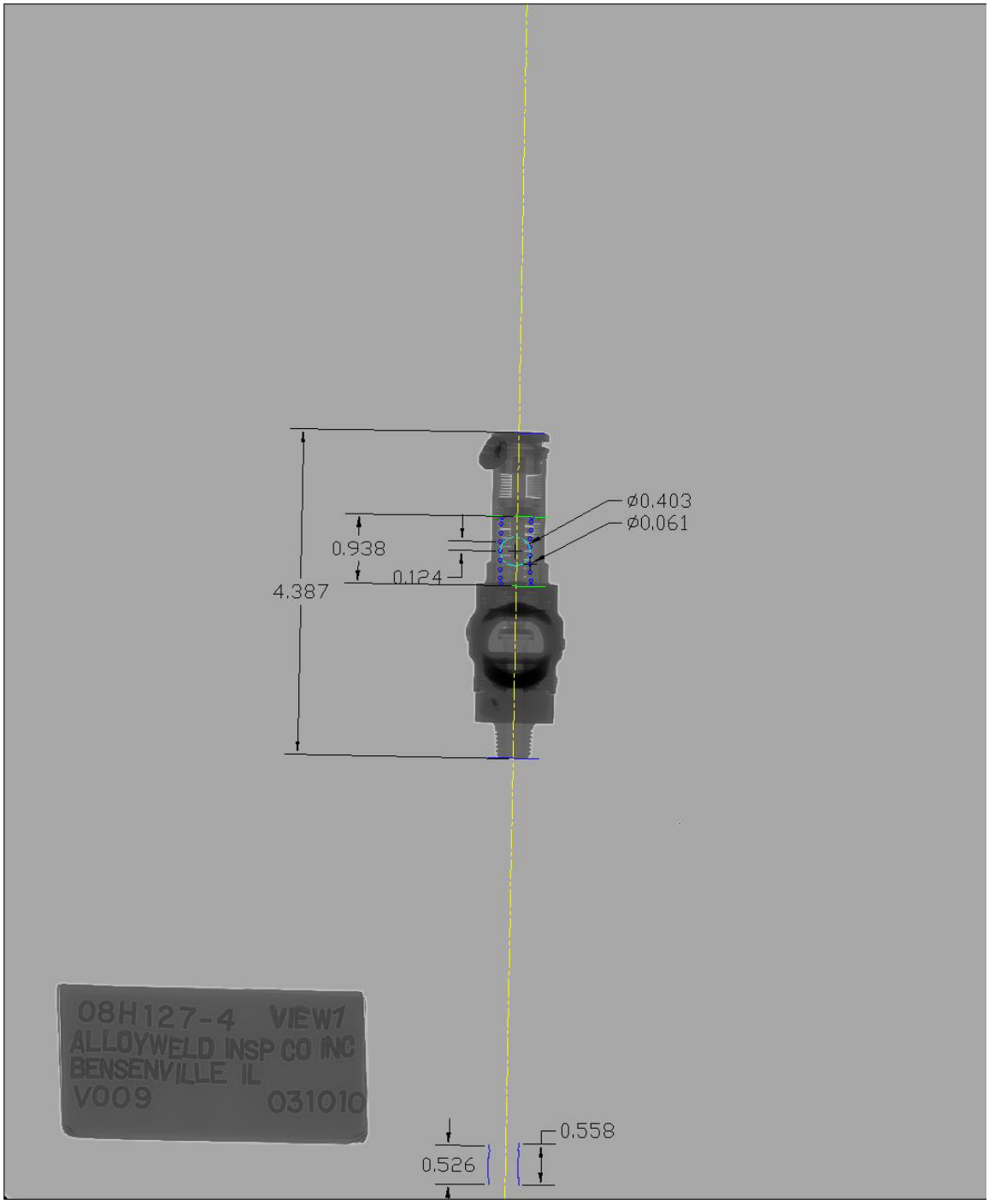

Ø0.988
Ø0.192
1.795
0.308
8.767
08H127-1 VIEW 2
ALLOYWELD INSP CO INC
BENSENVILLE IL
V009
031010

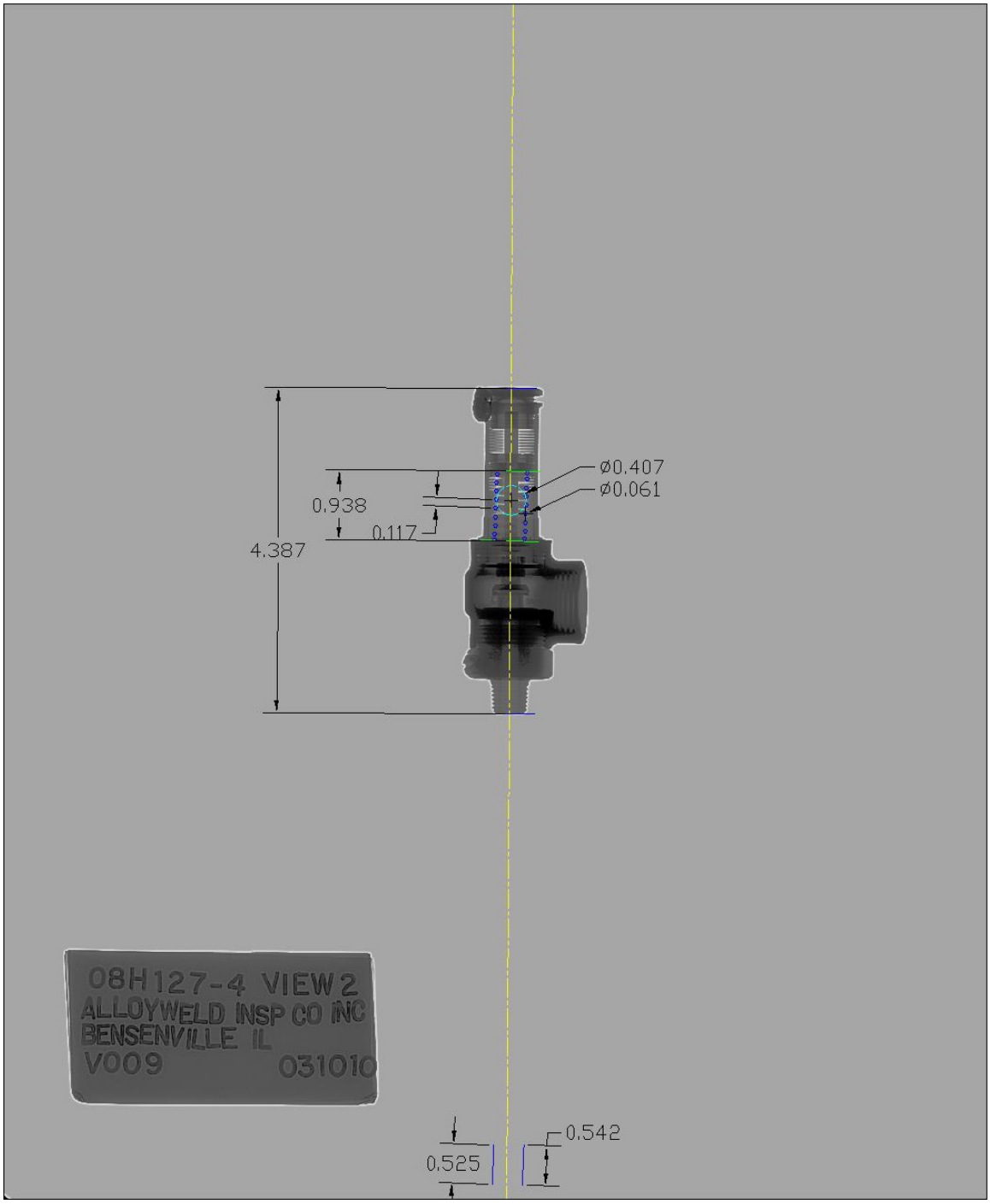

Ø0.984
Ø0.192
0.297
1.793
8.799
08H127-2 VIEW1
ALLOYWELD INSP CO INC
BENSENVILLE IL
V009
031010

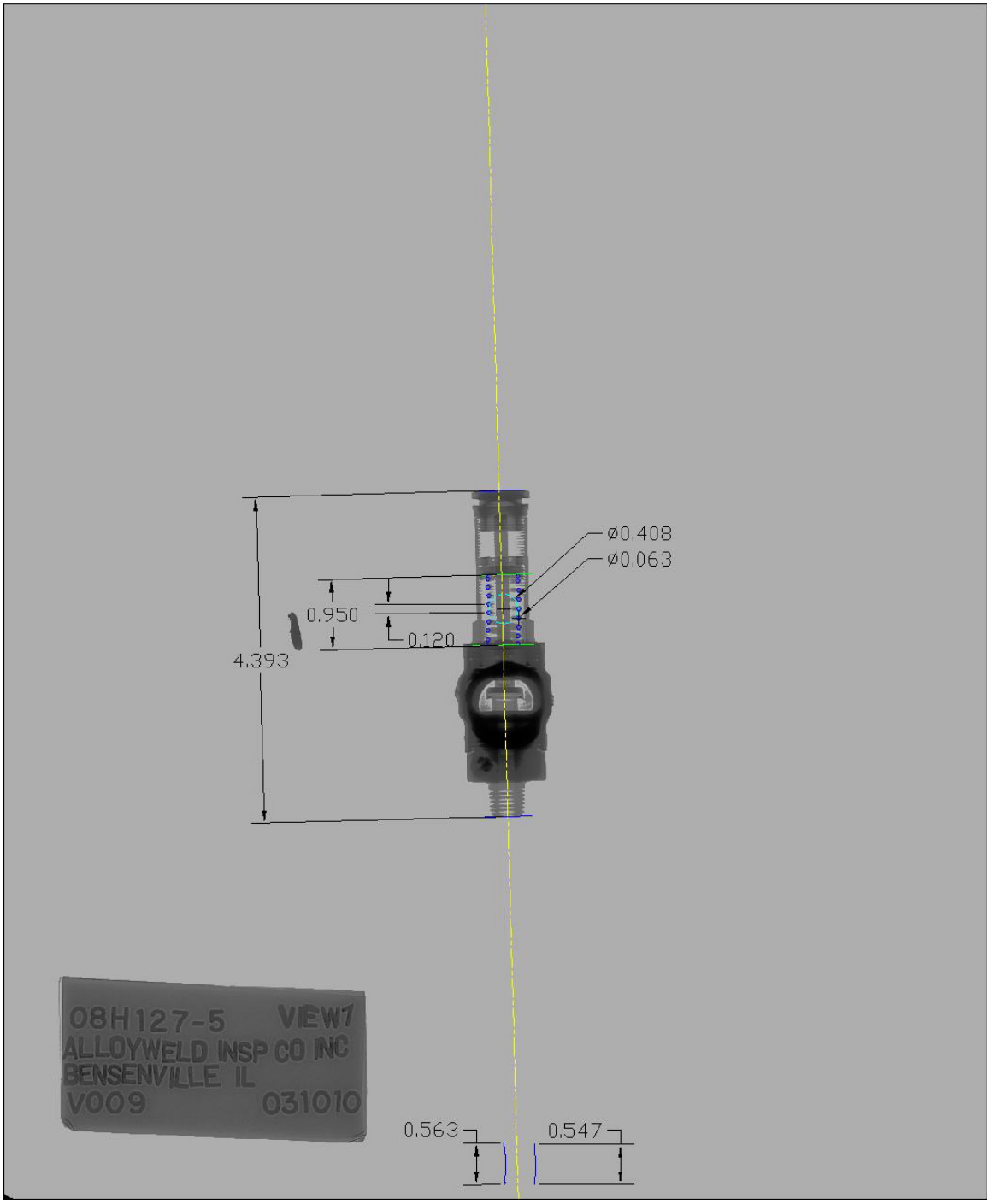

Ø0.984
Ø0.192
1.799
0.297
8.799
08H127-2 VIEW2
ALLOYWELD INSP CO INC
BENSENVILLE IL
V009
031010

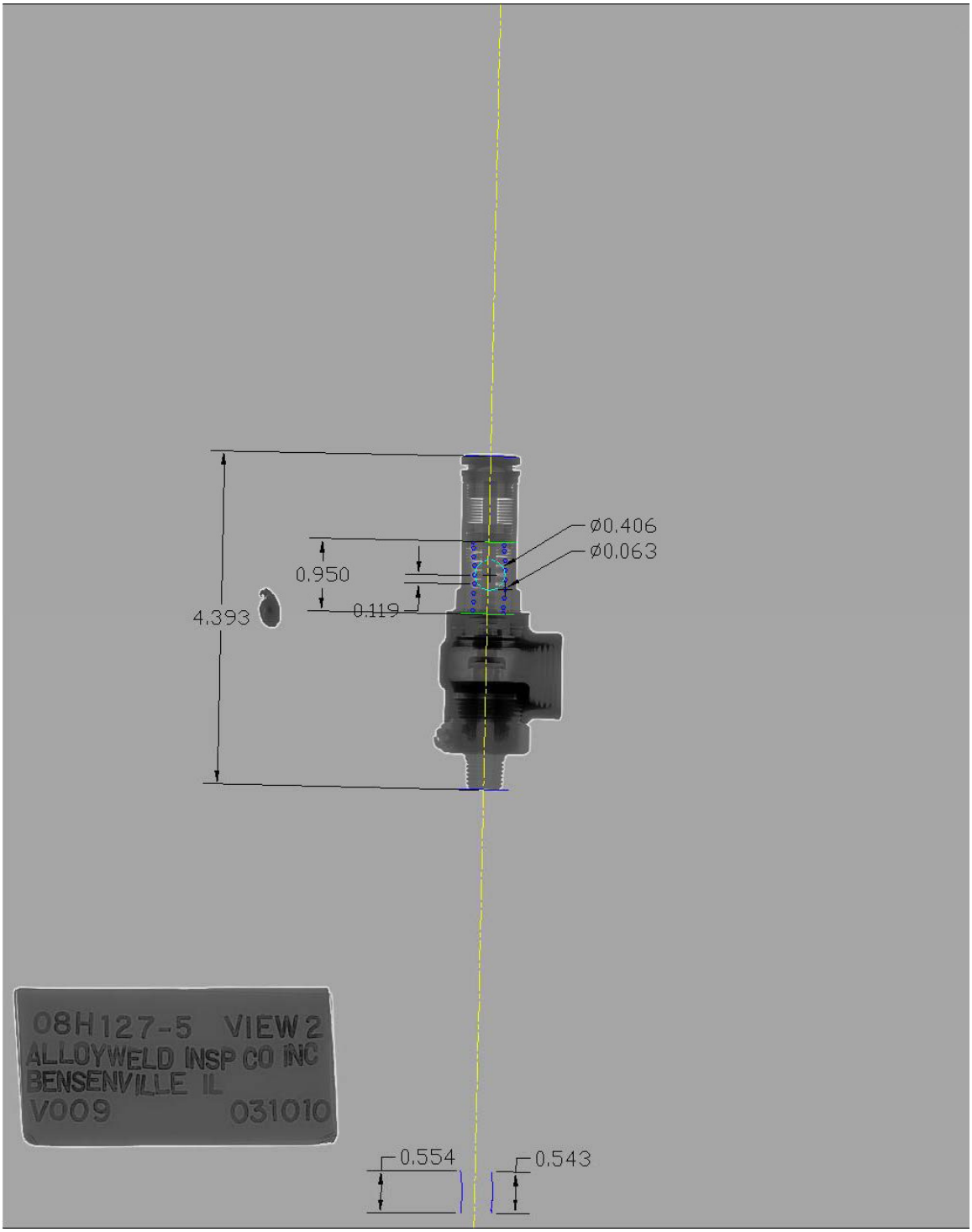

Ø1.003
Ø0.192
1.823
0.286
8.761
08H127-3 VIEW1
ALLOYWELD INSP CO INC
BENSENVILLE IL
V009
031010


Ø1.003
Ø0.192
1.823
0.289
8.761
08H127-3 VIEW 2
ALLOYWELD INSP CO INC
BENSENVILLE IL
V009
031010


ø0.403
ø0.061
0.938
0.124
4.387
08H127-4 VIEW1
ALLOYWELD INSP CO INC
BENSENVILLE IL
V009 031010
0.526
0.558


Ø0.407
Ø0.061
0.938
0.117
4.387
08H127-4 VIEW 2
ALLOYWELD INSP CO INC
BENSENVILLE IL
V009
031010
0.525
0.542

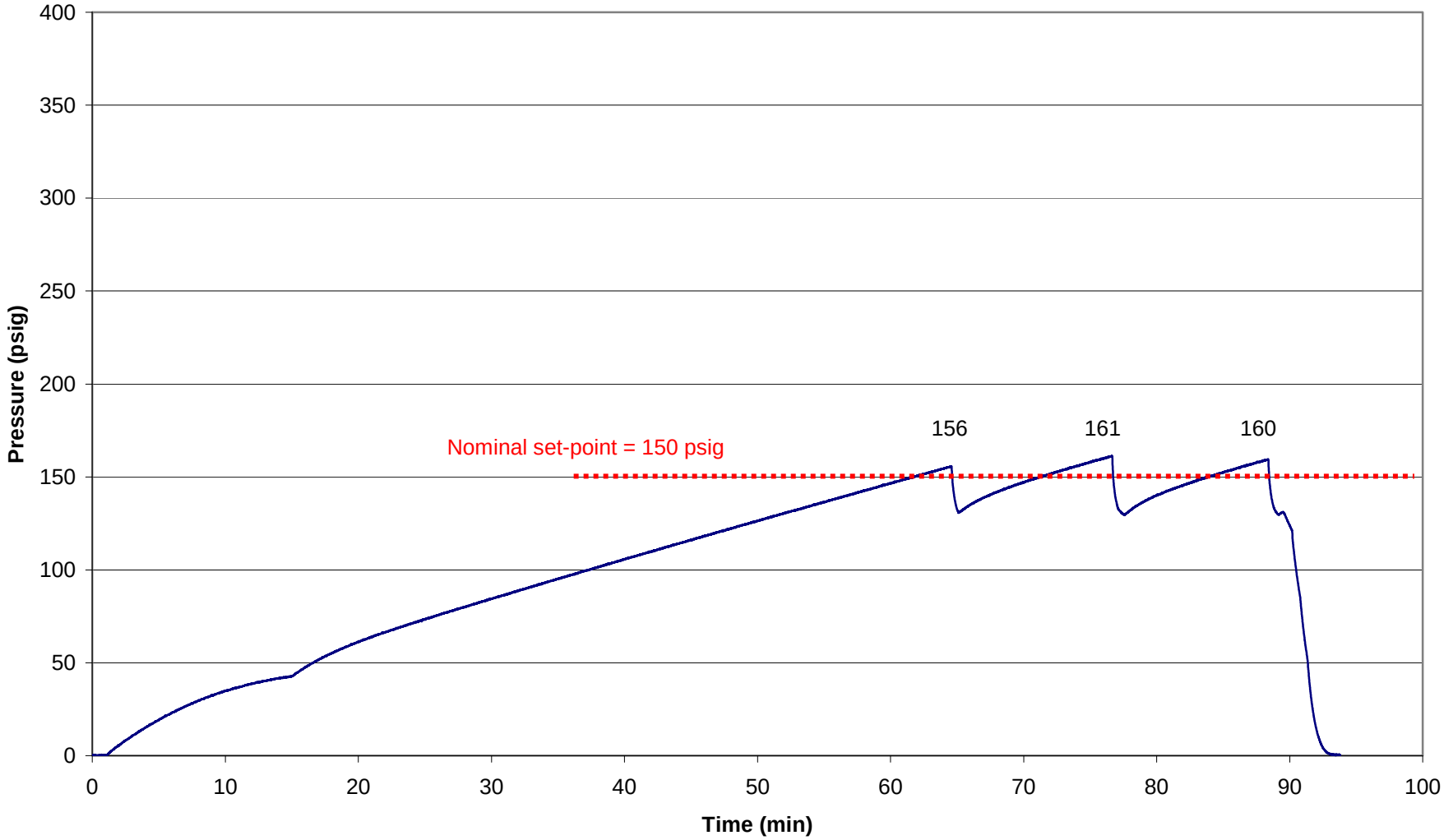

Ø0.408
Ø0.063
0.950
0.120
4.393
08H127-5 VIEW1
ALLOYWELD INSP CO INC
BENSENVILLE IL
V009 031010
0.563
0.547


Ø0.406
Ø0.063
0.950
0.119
4.393
08H127-5 VIEW 2
ALLOYWELD INSP CO INC
BENSENVILLE IL
V009 031010
0.554
0.543

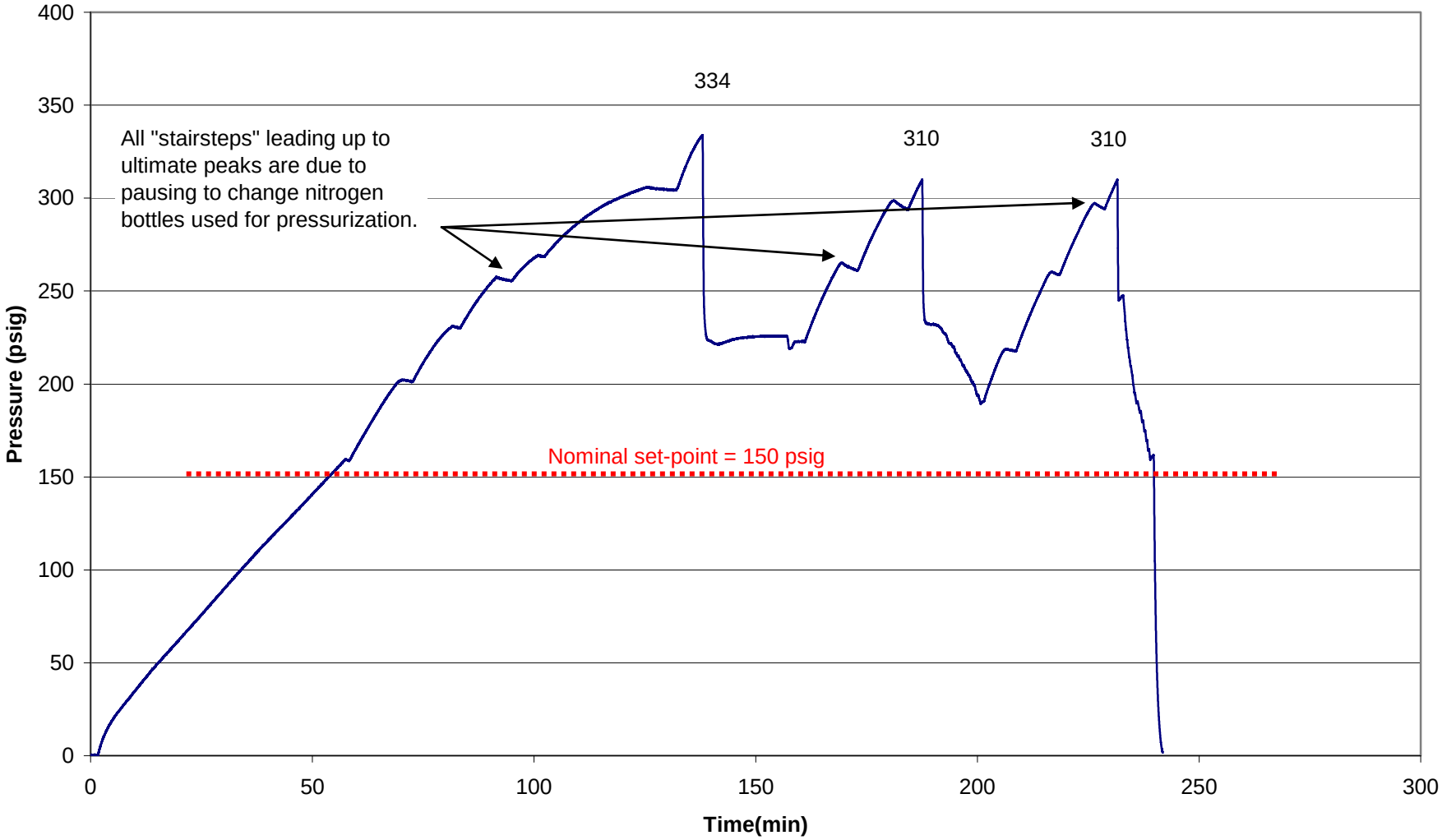


# Appendix C
# Pressure Test Data

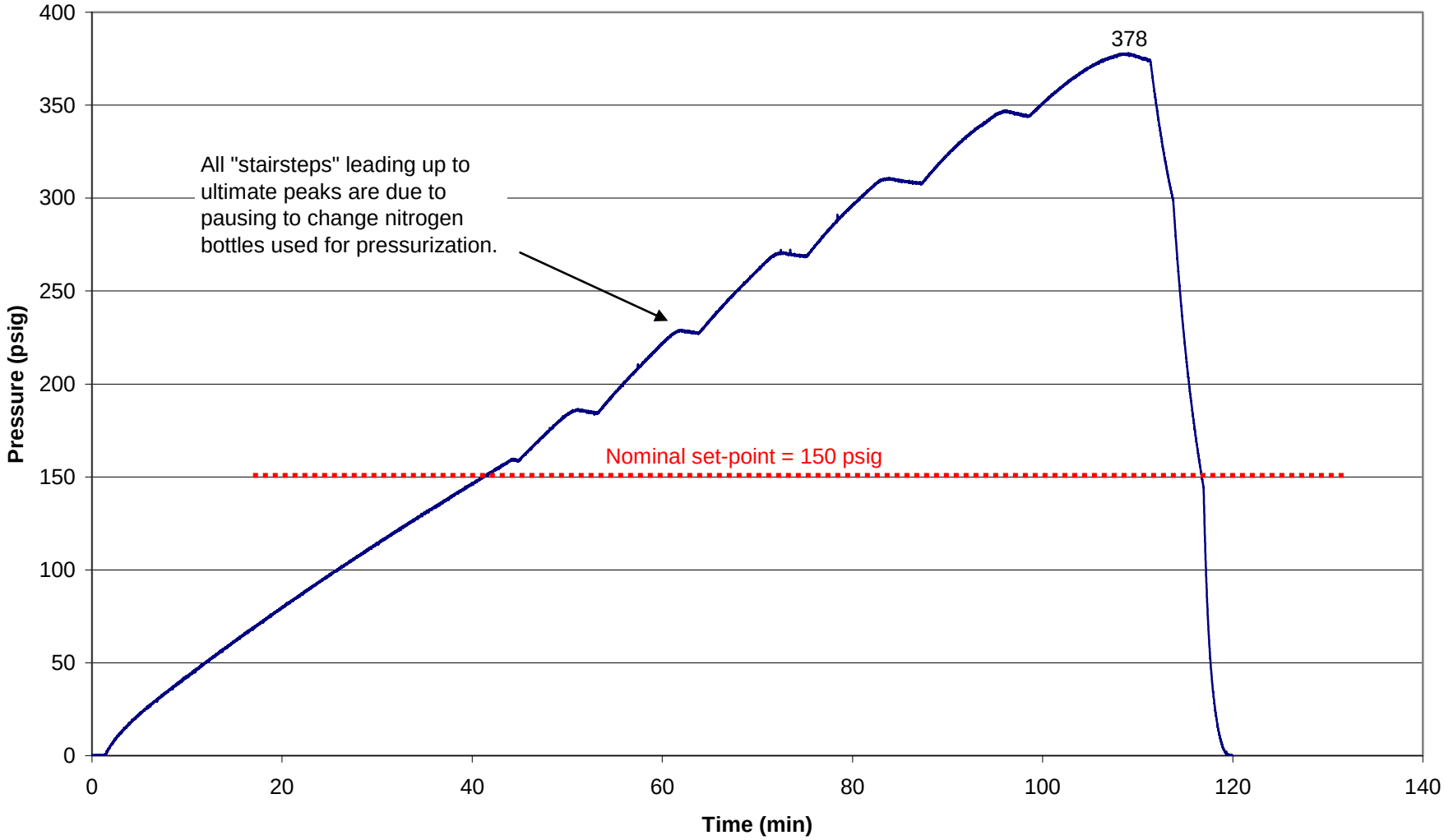
**Valve O8H127- Exemplar**
**(Exemplar Kunkle type 912)**



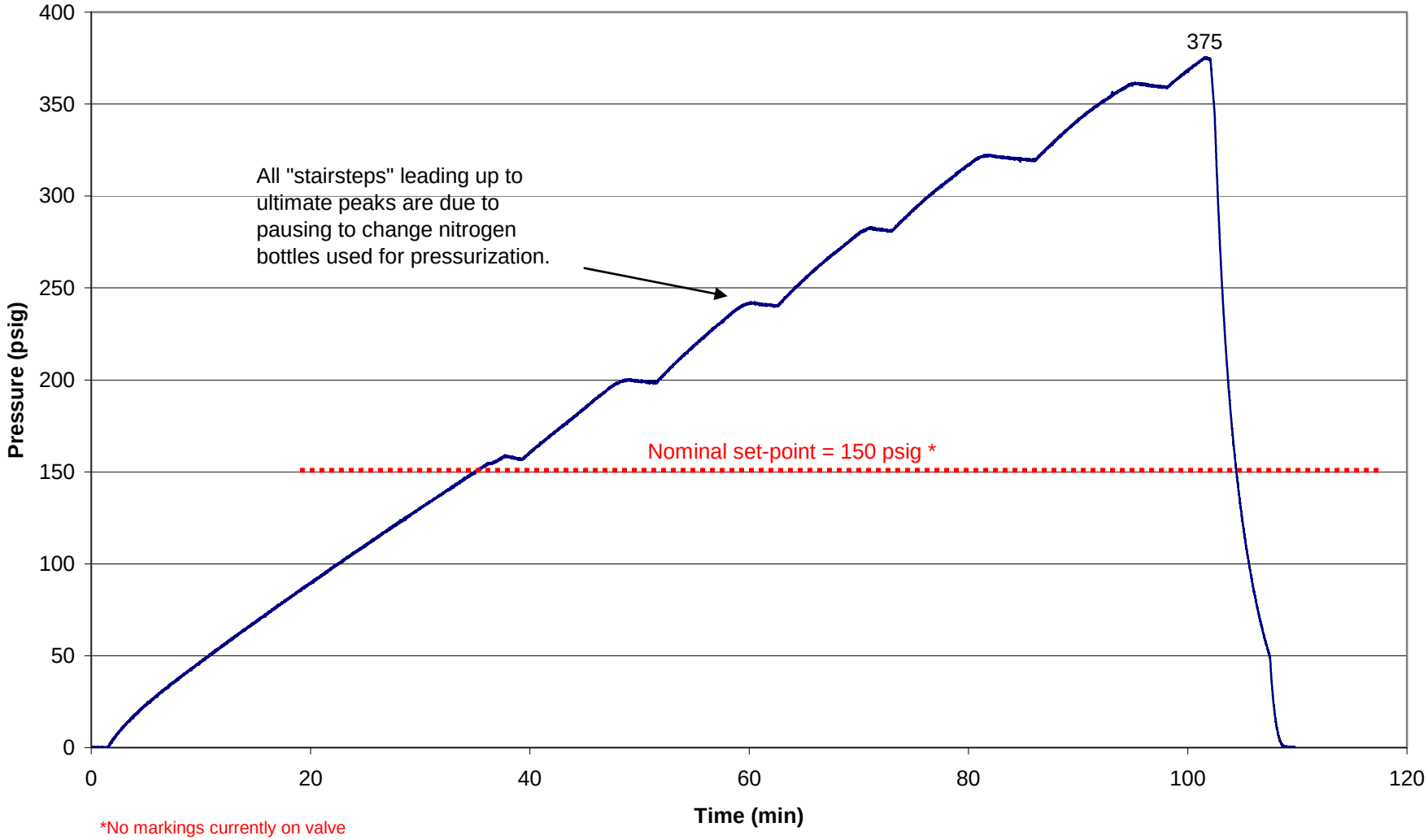
**Valve 08H127-1**
**(Subject Kunkle type 912)**



**Valve 08H127-2**
**(Subject Kunkle type 912)**

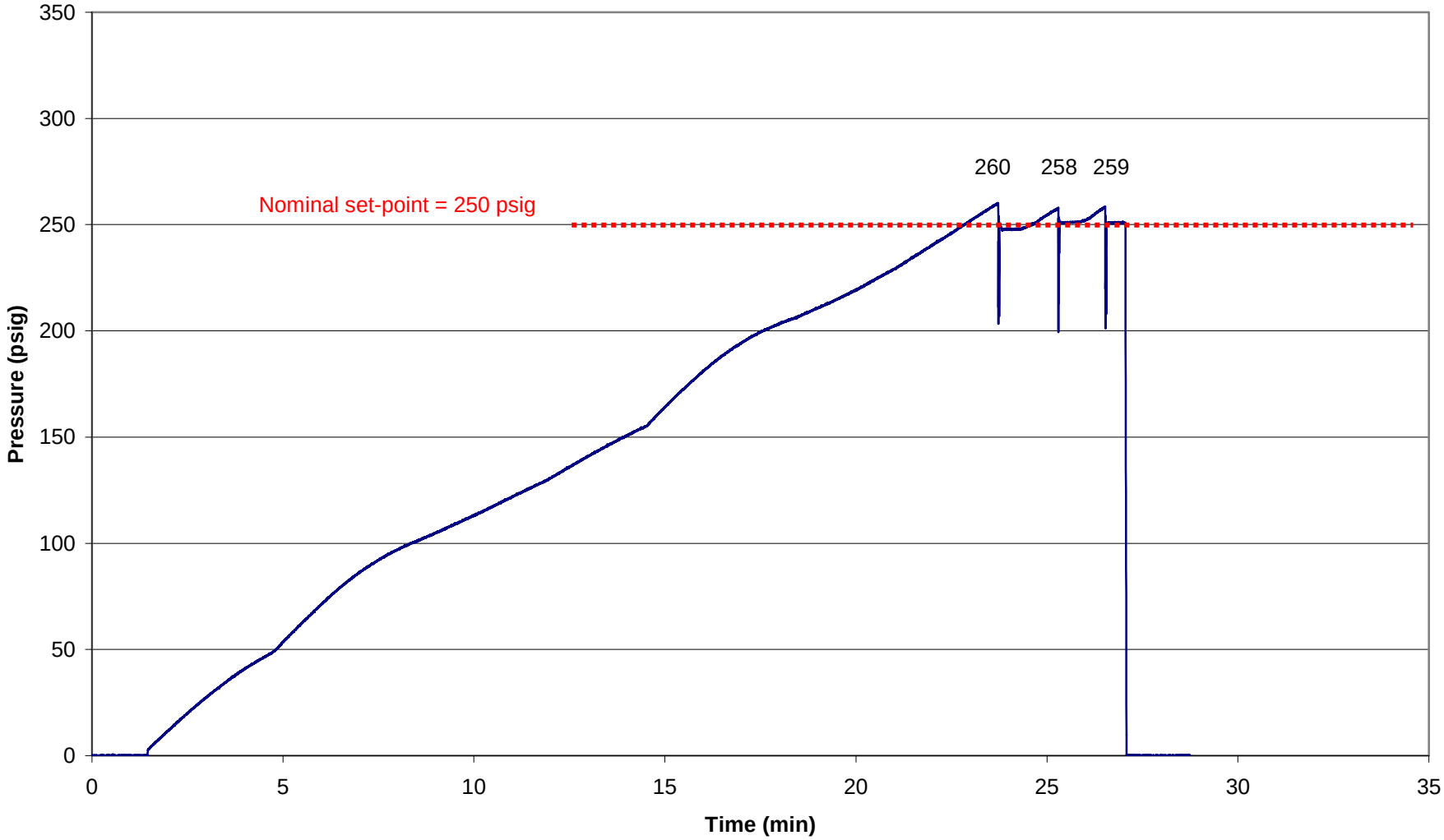


**Valve 08H127-3**
**(Subject Kunkle type 912)**




*No markings currently on valve

**Valve 08H127-4**
**(Subject Herose type 06474)**



**Valve 08H127-5**
**(Subject Herose type 06474)**