

Manufacturer : HY-LOK CORPORATION  
 Type : Compression Fittings with front and back ferrules

### Das Bauteil / The Specific Component

- |   |   |
|---|---|
| 1. Make (trade name of manufacturer)<br>Fabrikmarke                       | : Hy-Lok®<br>Hy-Lok®  |
| 2. Type<br>Typ  | : Compression Fittings with front and back ferrules<br>Doppelklemmringverschraubung |
| 3. Article<br>Art   | : Tube Fittings, Class 0<br>Fttinge / Verbindungsteile Klasse 0                     |
| 4. Name and address of manufacturer<br>Name und Anschrift des herstellers | : HY-LOK CORPORATION<br>1467-1, Songjeong-Dong, Gangseo-Gu,<br>Busan, Korea 618-270 |

Meets the requirements of ECE Regulation 110 Uniform provisions concerning the approval of Part I specific components of motor vehicles using compressed natural gases in their propulsion system including all amendments until Supplement 1 to the original version of the Regulation  
 - Date of entry into force : 2003-10-16 ;

And

International Standard ISO 15500  
 Road vehicles –Compressed natural gas (CNG) fuel system components  
 Part 2 including all Amendments until First edition ( 2001-2-15 )  
 Performance and general test requirements;

Part 19 including all amendments until First edition ( 2001-2-15 )  
 Fittings

- |   |                           |
|---|---------------------------|
| 5. Detail information                                   |                           |
| 5.1. List of tube fittings to be covered by the testing | : Appendix 0 (page 2 & 3) |
| 5.2. Test information                                   | : Item 1 (page 4)         |
| 5.3. Test minutes                                       | : Item 2 (page 5, 6 & 7)  |
| 5.4. Remark concerning tested object(s)                 | : Item 3 (page 8)         |
| 5.5. Statement of conformity                            | : Item 4 (page 8)         |

Cologne, January 31, 2004

YBR

Dipl.-Ing. Carlos Lee

Manufacturer : HY-LOK CORPORATION  
 Type : Compression Fittings with front and back ferrules

List of tube fittings to be covered by the testing

Appendix 0

| No. | Description               | Type(Series) | Connection Size |                 | Remark |
|-----|---------------------------|--------------|-----------------|-----------------|--------|
|     |                           |              | In Size         | Metric Size(mm) |        |
| 1   | Cap for Tube End          | CCA          | 1/4"            | 6               |        |
|     |                           |              | 3/8"            | 10              |        |
|     |                           |              | 1/2"            | 12              |        |
|     |                           |              | 3/4"            | 16              |        |
|     |                           |              | 1"              | 25              |        |
| 2   | Male Connector            | CMC          | 1/4"x1/4"NPT    | 6X1/4"PT        |        |
|     |                           |              | 3/8"x3/8"NPT    | 10X3/8"PT       |        |
|     |                           |              | 1/2"x1/2"NPT    | 12X1/2"PT       |        |
|     |                           |              | 3/4"x3/4"NPT    | 16X3/4"PT       |        |
| 3   | Male Adapter              | CAM          | 1/4"x1/4"NPT    | 6X1/4"PT        |        |
|     |                           |              | 3/8"x3/8"NPT    | 10X3/8"PT       |        |
|     |                           |              | 1/2"x1/2"NPT    | 12X1/2"PT       |        |
|     |                           |              | 3/4"x3/4"NPT    | 16X3/4"PT       |        |
| 4   | Bulkhead Female Connector | CBFC         | 1/4"x1/4"NPT    | 6x1/4"PT        |        |
|     |                           |              | 3/8"x3/8"NPT    | 10x3/8"PT       |        |
|     |                           |              | 1/2"x1/2"NPT    | 12x1/2"PT       |        |
| 5   | SAE/MS Male Connector     | CSC          | 1/4"xSAE9/16    |                 |        |
|     |                           |              | 3/8"xSAE9/16    |                 |        |
|     |                           |              | 1/2"xSAE9/16    |                 |        |
| 6   | Bulkhead Union            | CBU          | 1/4"            | 6               |        |
|     |                           |              | 3/8"            | 10              |        |
|     |                           |              | 1/2"            | 12              |        |
|     |                           |              | 3/4"            | 16              |        |
| 7   | Union                     | CUA          | 1/4"            | 6               |        |
|     |                           |              | 3/8"            | 10              |        |
|     |                           |              | 1/2"            | 12              |        |
|     |                           |              | 3/4"            | 16              |        |
|     |                           |              | 1"              | 25              |        |
| 8   | Union Tee                 | CTA          | 1/4"            | 6               |        |
|     |                           |              | 3/8"            | 10              |        |
|     |                           |              | 1/2"            | 12              |        |
|     |                           |              | 3/4"            | 16              |        |
|     |                           |              | 1"              | 25              |        |
| 9   | Union Cross               | CXA          | 1/4"            | 6               |        |
|     |                           |              | 3/8"            | 10              |        |
|     |                           |              | 1/2"            | 12              |        |
|     |                           |              | 3/4"            | 16              |        |
|     |                           |              | 1"              | 25              |        |
| 10  | Union Elbow               | CLA          | 1/4"            | 6               |        |
|     |                           |              | 3/8"            | 10              |        |
|     |                           |              | 1/2"            | 12              |        |
|     |                           |              | 3/4"            | 16              |        |
|     |                           |              | 1"              | 25              |        |

Manufacturer : HY-LOK CORPORATION  
 Type : Compression Fittings with front and back ferrules

|    |                |      |              |           |  |
|----|----------------|------|--------------|-----------|--|
| 11 | Port Connector | CPC  | 1/4"         | 6         |  |
|    |                |      | 3/8"         | 10        |  |
|    |                |      | 1/2"         | 12        |  |
|    |                |      |              | 16        |  |
| 12 | Male Elbow     | CLMA | 1/4"x1/4"NPT | 6X1/4"PT  |  |
|    |                |      | 3/8"x3/8"NPT | 10X3/8"PT |  |
|    |                |      | 1/2"x1/2"NPT | 12X1/2"PT |  |
|    |                |      | 3/4"x3/4"NPT | 16X3/4"PT |  |

Note : In above table Inch sizes and metric sizes are different size each other.

So to speak inch sizes are not corresponding sizes of the metric sizes

For example No 1 Cap for tube end have 5 inch sizes and 5 metric sizes, total 10 sizes.

Manufacturer : HY-LOK CORPORATION  
 Type : Compression Fittings with front and back ferrules

## 0. General information

0.1 Make (trade name of manufacturer) : Hy-Lok  
 0.2 Type : Compression Fittings with front and back ferrules  
 0.3 Article : Tube Fittings, Class 0  
 0.4 Name and address of manufacturer : HY-LOK CORPORATION  
 1467-1, Songjeong-Dong, Gangseo-Gu,  
 Busan, Korea 618-270  
 0.5 No. of information folder : ---

## 1 Test Information

1.1 Test object(s) :

| Sample Identification | Tube size | Wall thickness             | Fitting Materials  |
|-----------------------|-----------|----------------------------|--|
| C030349 and C030349/1 | 6 mm      | 1.0 mm & 1.5 mm            | Barstock : ASTM A479 Type 316<br>Forging : ASTM A182 F316<br>X 5CrNiMo 17-12-2 (1.4401) /<br>316 (UNS S 31600) |
| C030350 and C030350/1 | 3/8 inch  | 0.035 inch &<br>0.065 inch |  |
| C030351 and C030351/1 | 12 mm     | 1.0 mm & 2.0 mm            | Tubing materials : ASTM A269 / A213 Type 316/L<br>DIN 17458 (1.4401 / 1.4404)                                  |
| C030352 and C030352/1 | 1 inch    | 0.083 inch & 0.109 inch    |  |

1.2 Test date : September 2003 - December 2003  
 1.3 Test site : GASTEC Certification BV, the Netherlands  
 1.4 Remark : The results of the test refer exclusively to the object(s) mentioned under point 1.1 of this report.

Manufacturer : HY-LOK CORPORATION  
 Type : Compression Fittings with front and back ferrules

## 2 Test minutes

2.1 Test facilities : The test equipment used was in compliance with the requirements of the regulation and / or the standard.

2.2 Hydrostatic strength test according to ISO 15500 part 2 clause 5 and part 19 clause 6.2

### 2.2.1 Test results

| Sample Identification | Tube size | Wall thickness          | Test pressure | Test time | Rupture | Permanent distortion |
|-----------------------|-----------|-------------------------|---------------|-----------|---------|----------------------|
| C030349               | 6 mm      | 1.0 mm & 1.5 mm         | 100 Mpa       | 5 min.    | No      | No                   |
| C030350 and C030350/1 | 3/8 inch  | 0.035 inch & 0.065 inch | 100 Mpa       | 5 min.    | No      | No                   |
| C030351               | 12 mm     | 1.0 mm & 2.0 mm         | 100 Mpa       | 5 min.    | No      | No                   |
| C030352/1             | 1 inch    | 0.083 inch & 0.109 inch | 100 Mpa       | 5 min.    | No      | No                   |
| Requirements          |           |                         | 100 Mpa       | > 3.0 min | No      | No                   |

2.2.2 Conclusion : The samples comply with the requirements.  
 The test results cover ECE R. 110 requirements as well.

2.3 External leakage test including high and low temperature according to : ECE R. 110 annex 5B

### 2.3.1 Test results

| Sample Identification            | Tube size | Wall thickness          | Test temperature       | Test pressure          | External leakage      |
|----------------------------------|-----------|-------------------------|------------------------|------------------------|-----------------------|
| C030349 before & after vibration | 6 mm      | 1.0 mm & 1.5 mm         | all                    | 39 Mpa                 | 0                     |
| C030350 before & after vibration | 3/8 inch  | 0.035 inch & 0.065 inch | all                    | 39 Mpa                 | 0                     |
| C030351 before & after corrosion | 12 mm     | 1.0 mm & 2.0 mm         | all                    | 39 Mpa                 | 0                     |
| C030352 before & after corrosion | 1 inch    | 0.083 inch & 0.109 inch | all                    | 39 Mpa                 | 0                     |
| Requirements                     |           |                         | Room / 120 °C / -40 °C | Working pressure x 1.5 | Lower than 15 cc/hour |

Manufacturer : HY-LOK CORPORATION  
 Type : Compression Fittings with front and back ferrules

2.3.2 Conclusion : The samples comply with the requirements.  
 The test results cover ISO 15500 requirements as well.

2.4 Corrosion resistance test (Salt spray test) : ECE R. 110 Annex 5E  
 according to

#### 2.4.1 Test results

| Sample Identification                         | Tube size | Wall thickness          | Salt spray testing time                     | Ambient temperature | Store time at room temperature |
|---|-----------|-------------------------|---|---------------------|--------------------------------|
| C030351                                       | 12 mm     | 1.0 mm & 2.0 mm         | 144 hour                                    | 35 °C               | 1 hour                         |
| C030352                                       | 1 inch    | 0.083 inch & 0.109 inch | 144 hour                                    | 35 °C               | 1 hour                         |
| Requirements                                  |           |                         | 144 hour                                    | 33 – 36 °C          | 0.5 – 1 hour                   |
| Test to be performed after the endurance test |           |                         | The external leakage test – see above 2.3.1 |                     |                                |

2.4.2 Conclusion : The samples comply with the requirements.  
 The test results cover ISO 15500 requirements as well.

2.5 Vibration resistance test according to : ECE R. 110 Annex 5N

#### 2.5.1 Test results

| Sample Identification | Tube size | Wall thickness          | Results  |
|-----------------------|-----------|-------------------------|--|
| C030349               | 6 mm      | 1.0 mm & 1.5 mm         | The components remain undamaged, continue to operate and comply with the leakage test after the vibration test of 6 hours was carried out. |
| C030350               | 3/8 inch  | 0.035 inch & 0.065 inch |  |

2.5.2 Conclusion : The samples comply with the requirements.  
 The test results cover ISO 15500 requirements as well.

Manufacturer : HY-LOK CORPORATION  
 Type : Compression Fittings with front and back ferrules

2.6 Excess torque resistance test according to : ISO 15500 part 2 clause 7

#### 2.6.1 Test results

| Sample Identification | Tube size | Wall thickness  | Position | Dimension | Declared torque | Test torque             | Test time       | Deformation or breakage after test |
|-----------------------|-----------|-----------------|----------|-----------|-----------------|-------------------------|-----------------|------------------------------------|
| C030349/1             | 6 mm      | 1.0 mm & 1.5 mm | Male     | 1/4 inch  | NA              | 35 Nm                   | 900 sec         | None                               |
|                       |           |                 | Female   | 1/4 inch  | NA              | 35 Nm                   | 900 sec         | None                               |
| C030351/1             | 12 mm     | 1.0 mm & 2.0 mm | Male     | 1/2 inch  | NA              | 85 Nm                   | 900 sec         | None                               |
|                       |           |                 | Female   | 1/2 inch  | NA              | 85 Nm                   | 900 sec         | None                               |
| Requirements          |           |                 | -        | -         | -               | 150 % of declared value | 900 sec or more | None                               |

2.6.2 Conclusion : The samples comply with the requirements.

2.7 Non-metallic synthetic immersion test according to : ISO 15500 part 2 clause 13.1 & 13.2

#### 2.7.1 Test results

| Sample Identification | Before immersion      |                       | After immersion       |                       | Swelling       | Weight change      |
|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|----------------|--------------------|
|                       | Above water (mass, g) | Under water (mass, g) | Above water (mass, g) | Under water (mass, g) |                |                    |
| O ring                | 0.20119               | 0.06580               | 0.20461               | 0.06211               | 5.2            | 1.7                |
|                       | 0.20450               | 0.06710               | 0.20766               | 0.06447               | 4.2            | 1.5                |
|                       | 0.15478               | 0.05039               | 0.15723               | 0.04879               | 3.9            | 1.6                |
| Requirements          | -                     | -                     | -                     | -                     | > - 1 & < 20 % | not more than 10 % |

2.7.2 Conclusion : The samples comply with the requirements.



Manufacturer : HY-LOK CORPORATION  
Type : Compression Fittings with front and back ferrules

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- 3 Remark concerning tested object(s)** : All components as listed in the appendix 0 are covered with the tested object(s).

**4 Statement of conformity**

The test laboratory is accredited for the above mentioned tests by the accreditation body of the RDW, Netherlands.

The technical report comprises the pages 1 to 8 (including appendix 0) and shall not be reproduced except in full without the written approval of the test laboratory.



# TECHNICAL REPORT

No.: 83-EIHP-33009246-100



Manufacturer : HY-LOK CORPORATION  
Type : Compression Fittings with front and back ferrules

## Das Bauteil / The Specific Component

- |    |  |   |
|----|--|---|
| 1  | Make (trade name of manufacturer)<br>Fabrikmarke                       | : Hy-Lok®<br>Hy-Lok®  |
| 2. | Type<br>Typ  | : Compression Fittings with front and back ferrules<br>Doppelklemmringverschraubung |
| 3. | Article<br>Art   | : Tube Fittings, Class 0<br>Fittinge / Verbindungsteile Klasse 0                    |
| 4. | Name and address of manufacturer<br>Name und Anschrift des herstellers | : HY-LOK CORPORATION<br>1467-1, Songjeong-Dong, Gangseo-Gu,<br>Busan, Korea 618-270 |

Meets EIHP draft, UNIFORM PROVISIONS CONCERNING THE APPROVAL OF SPECIFIC COMPONENTS OF MOTOR VEHICLES USING COMPRESSED GASEOUS HYDROGEN Rev. 12b dated 12.10..2003, annex 08 and Trans/WP. 29/GRPE/2003/14 7-03-2003, The following program is applicable.

- Pressure test;
- External leakage test at different temperatures;
- Resistance to corrosion + leakage test at different temperatures;
- Resistance to dry heat test with respect to O ring;
- Connection test + leakage test at different temperatures.
- Hydrogen compatibility test

## 5. Detail information

- |   |                                    |
|---|------------------------------------|
| 5.1. List of tube fittings to be covered by the testing | : Appendix 0 (page 2 & 3)          |
| 5.2. Test information                                   | : Item 1 (page 4)                  |
| 5.3. Test minutes                                       | : Item 2 (page 5, 6, 7, 8, 9 & 10) |
| 5.4. Remark concerning tested object(s)                 | : Item 3 (page 10)                 |
| 5.5. Statement of conformity                            | : Item 4 (page 10)                 |

Cologne, June 30, 2005

YBR

Dipl.-Ing. Carlos Lee



# TECHNICAL REPORT

No.: 83-EIHP-33009246-100

Manufacturer : HY-LOK CORPORATION  
Type : Compression Fittings with front and back ferrules

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2.7 Hydrogen compatibility : Trans/WP. 29/GRPE/2004/3 Annex 8B

2.7.1 Test results

The material of the tube fittings, type 316 is confirmed to be compatible for hydrogen service by US NASA reports without performing actual test

The tube fitting materials comply with the hydrogen compatibility requirements.

3 Remark concerning tested object(s) : All components as listed in the appendix 0 are covered with the tested object(s).

## 4 Statement of conformity

The test laboratory is accredited for the above mentioned tests by the accreditation body of the RDW, Netherlands.

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# TECHNICAL REPORT

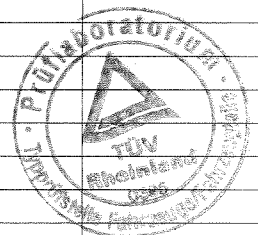
No.: 83-EIHP-33009246-100

Manufacturer : HY-LOK CORPORATION  
Type : Compression Fittings with front and back ferrules

List of tube fittings to be covered by the testing

Appendix 0

| No. | Description               | Type(Series) | Connection Size |                 | Remark |
|-----|---------------------------|--------------|-----------------|-----------------|--------|
|     |                           |              | In Size         | Metric Size(mm) |        |
| 1   | Cap for Tube End          | CCA          | 1/4"            | 6               |        |
|     |                           |              | 3/8"            | 10              |        |
|     |                           |              | 1/2"            | 12              |        |
|     |                           |              | 3/4"            | 16              |        |
|     |                           |              | 1"              | 25              |        |
| 2   | Male Connector            | CMC          | 1/4"x1/4"NPT    | 6X1/4"PT        |        |
|     |                           |              | 3/8"x3/8"NPT    | 10X3/8"PT       |        |
|     |                           |              | 1/2"x1/2"NPT    | 12X1/2"PT       |        |
|     |                           |              | 3/4"x3/4"NPT    | 16X3/4"PT       |        |
| 3   | Male Adapter              | CAM          | 1/4"x1/4"NPT    | 6X1/4"PT        |        |
|     |                           |              | 3/8"x3/8"NPT    | 10X3/8"PT       |        |
|     |                           |              | 1/2"x1/2"NPT    | 12X1/2"PT       |        |
|     |                           |              | 3/4"x3/4"NPT    | 16X3/4"PT       |        |
| 4   | Bulkhead Female Connector | CBFC         | 1/4"x1/4"NPT    | 6x1/4"PT        |        |
|     |                           |              | 3/8"x3/8"NPT    | 10x3/8"PT       |        |
|     |                           |              | 1/2"x1/2"NPT    | 12x1/2"PT       |        |
| 5   | SAE/MS Male Connector     | CSC          | 1/4"xSAE9/16    |                 |        |
|     |                           |              | 3/8"xSAE9/16    |                 |        |
|     |                           |              | 1/2"xSAE9/16    |                 |        |
| 6   | Bulkhead Union            | CBU          | 1/4"            | 6               |        |
|     |                           |              | 3/8"            | 10              |        |
|     |                           |              | 1/2"            | 12              |        |
|     |                           |              | 3/4"            | 16              |        |
| 7   | Union                     | CUA          | 1/4"            | 6               |        |
|     |                           |              | 3/8"            | 10              |        |
|     |                           |              | 1/2"            | 12              |        |
|     |                           |              | 3/4"            | 16              |        |
|     |                           |              | 1"              | 25              |        |
| 8   | Union Tee                 | CTA          | 1/4"            | 6               |        |
|     |                           |              | 3/8"            | 10              |        |
|     |                           |              | 1/2"            | 12              |        |
|     |                           |              | 3/4"            | 16              |        |
|     |                           |              | 1"              | 25              |        |
| 9   | Union Cross               | CXA          | 1/4"            | 6               |        |
|     |                           |              | 3/8"            | 10              |        |
|     |                           |              | 1/2"            | 12              |        |
|     |                           |              | 3/4"            | 16              |        |
|     |                           |              | 1"              | 25              |        |
| 10  | Union Elbow               | CLA          | 1/4"            | 6               |        |
|     |                           |              | 3/8"            | 10              |        |
|     |                           |              | 1/2"            | 12              |        |
|     |                           |              | 3/4"            | 16              |        |
|     |                           |              | 1"              | 25              |        |



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No.: 83-EIHP-33009246-100

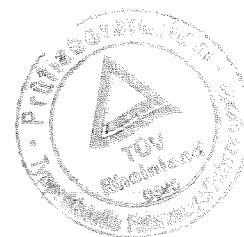
Manufacturer : HY-LOK CORPORATION  
Type : Compression Fittings with front and back ferrules

|    |                |      |              |           |  |
|----|----------------|------|--------------|-----------|--|
| 11 | Port Connector | CPC  | 1/4"         | 6         |  |
|    |                |      | 3/8"         | 10        |  |
|    |                |      | 1/2"         | 12        |  |
|    |                |      |              | 16        |  |
| 12 | Male Elbow     | CLMA | 1/4"x1/4"NPT | 6X1/4"PT  |  |
|    |                |      | 3/8"x3/8"NPT | 10X3/8"PT |  |
|    |                |      | 1/2"x1/2"NPT | 12X1/2"PT |  |
|    |                |      | 3/4"x3/4"NPT | 16X3/4"PT |  |

Note : In above table Inch sizes and metric sizes are different size each other.

So to speak inch sizes are not corresponding sizes of the metric sizes

For example No 1 Cap for tube end have 5 inch sizes and 5 metric sizes, total 10 sizes.



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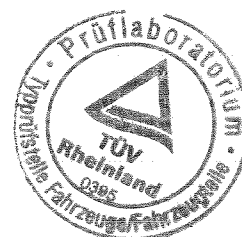
Manufacturer : HY-LOK CORPORATION  
Type : Compression Fittings with front and back ferrules

## 1 Test Information

1.1 Test object(s) :

| Sample Identification   | Tube size  | Wall thickness             | Fitting Materials   |
|---|--|----------------------------|---|
| C040512   | 6 mm   | 1.0 mm & 1.5 mm            | Barstock : ASTM A479 Type 316   |
| C040494, C040495,<br>C040496, C040497,<br>C040498 and C040513 | 3/8 inch   | 0.035 inch &<br>0.065 inch | Forging : ASTM A182 F316<br>X 5CrNiMo 17-12-2 (1.4401) /<br>316 (UNS S 31600) |
| C040514   | 12 mm  | 1.0 mm & 2.0 mm            | Tubing materials : ASTM A269 / A213 Type 316/L<br>DIN 17458 (1.4401 /1.4404)  |
| C040515   | 1 inch   | 0.083 inch & 0.109<br>inch |   |
| O ring  | Rubber O-rings with code V75<br>dimension approximately 12.0 mm x 2.0 mm |                            |   |

1.2 Test date : August to September 2004 & June 2005  
1.3 Test site : GASTEC Certification BV, the Netherlands  
1.4 Remark : The results of the test refer exclusively to the object(s)  
mentioned under point 1.1 of this report.



# TECHNICAL REPORT

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Type : Compression Fittings with front and back ferrules

## 2 Test minutes

2.1 Test facilities : The test equipment used was in compliance with the requirements of the regulation and / or the standard.

2.2 External leakage test including high & low temperature in accordance with : Trans/WP. 29/GRPE/2003/14 Annex 8B

### 2.2.1 Test results

| Test results        | Requirement     | Sample no. C040512, C040513, C040514 & C040515 |              |              |              |              |              |
|---------------------|-----------------|--|--------------|--------------|--------------|--------------|--------------|
| Test temperature    | ---             | Room temperature                               |              | 85/105/120°C |              | - 40°C       |              |
| Moment of test      | Corrosion       | Before   | After        | Before       | After        | Before       | After        |
| Test pressure (Bar) | 0.02 x NWp      | 4.2  | 4.2          | 4.2          | 4.2          | 4.2          | 4.2          |
| External leakage    | ≤ 15 cc/hr      | 0  | 0            | 0            | 0            | 0            | 0            |
| Test pressure (Bar) | NWP             | 210  | 210          | ---          | ---          | 210          | 210          |
| Test pressure (Bar) | NWP x 1.37      | ---  | ---          | 287          | 287          | ---          | ---          |
| External leakage    | ≤ 15 cc/hr      | 0  | 0            | 0            | 0            | 0            | 0            |
| Test date           | To be monitored | Aug. 4, 2004                                   | Sept. 4 2004 | Aug. 4, 2004 | Sept. 4 2004 | Aug. 4, 2004 | Sept. 4 2004 |

\* NWP=Normal working pressure (210 bar)

2.2.2 Conclusion : The samples comply with the requirements.



# TECHNICAL REPORT

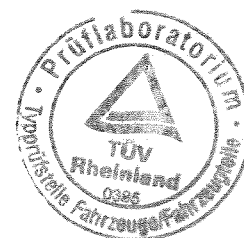
No.: 83-EIHP-33009246-100

Manufacturer : HY-LOK CORPORATION  
Type : Compression Fittings with front and back ferrules

2.3 Corrosion test (Salt spray) in accordance with : Trans/WP. 29/GRPE/2003/14 Annex 8B

## 2.3.1 Test results

|  |                            |  |
|--|----------------------------|--|
| Test results   | Requirement                | Sample no. C040512, C040513, C040514 & C040515 |
| Date & time starting the test                        | To be monitored            | August 2004                                    |
| Date & time stopping the test                        | To be monitored            | September 2004                                 |
| Salt spray testing time                              | 144 hours                  | 144  |
| Ambient temperature during the test                  | $35 \pm 2^{\circ}\text{C}$ | 35   |
| Store time at room temperature                       | 0.5 – 1.0 hour             | 1  |
| Tests to be performed after the endurance test are : |                            |  |
| External leakage test                                | ---                        | See above 2.2                                  |
| Internal leakage test                                | ---                        | ---  |





# TECHNICAL REPORT

No.: 83-EIHP-33009246-100

Manufacturer : HY-LOK CORPORATION  
Type : Compression Fittings with front and back ferrules

2.4 Overpressure test in accordance with : Trans/WP. 29/GRPE/2003/14 Annex 8B

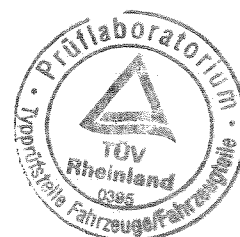
## 2.4.1 Test results

| Test results         | Requirement     | Sample no. C040512, C040513, C040514 & C040515 |       |              |       |              |       |
|----------------------|-----------------|--|-------|--------------|-------|--------------|-------|
| Moment of test       | ---             | Before   | After | Before       | After | Before       | After |
| Test pressure (Bar)  | 1.5 x MAWP      | 315  | N/A   | 315          | N/A   | 315          | N/A   |
| Test time            | $\geq 3$ min    | 5  | N/A   | 5            | N/A   | 5            | N/A   |
| Rupture              | No              | No   | N/A   | No           | N/A   | No           | N/A   |
| Permanent distortion | No              | No   | N/A   | No           | N/A   | No           | N/A   |
| Test pressure (Bar)  | 3.0 x MAWP      | 630  | N/A   | 630          | N/A   | 630          | N/A   |
| Test time            | $\geq 3$ min    | 5  | N/A   | 5            | N/A   | 5            | N/A   |
| Rupture              | No              | No   | N/A   | No           | N/A   | No           | N/A   |
| Permanent distortion | No              | No   | N/A   | No           | N/A   | No           | N/A   |
| Test date            | To be monitored | Sep. 4, 2004                                   | N/A   | Sep. 4, 2004 | N/A   | Sep. 4, 2004 | N/A   |

\* N/A : Not applicable

\* MAWP : maximum allowable working pressure

2.4.2 Conclusion : The samples comply with the requirements.



# TECHNICAL REPORT

No.: 83-EIHP-33009246-100

Manufacturer : HY-LOK CORPORATION  
Type : Compression Fittings with front and back ferrules

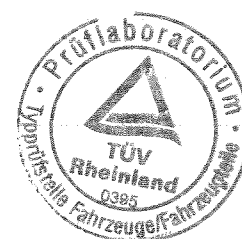
2.5 **Endurance test** including high & low temperature : Trans/WP. 29/GRPE/2003/14 Annex 8B (Leak tightness)  
in accordance with

Draft ECE regulation revision 12b dated 12-10-2003  
(Endurance test)

## 2.5.1 Test results

|                     |                                   |  |                 |                 |                 |                 |                 |
|---------------------|-----------------------------------|--|-----------------|-----------------|-----------------|-----------------|-----------------|
| Test results        | Requirement                       | Sample no. C040512, C040513, C040514 & C040515 |                 |                 |                 |                 |                 |
| Test temperature    | ---                               | Room temperature                               |                 | 85/105/120°C    |                 | - 40°C          |                 |
| Moment of test      | 25 connections/<br>disconnections | Before   | After           | Before          | After           | Before          | After           |
| Test pressure (Bar) | 0.02 x NWp                        | 4.2  | 4.2             | 4.2             | 4.2             | 4.2             | 4.2             |
| External leakage    | ≤ 15 cc/hr                        | 0  | 0               | 0               | 0               | 0               | 0               |
| Test pressure (Bar) | NWp                               | 210  | 210             | ---             | ---             | 210             | 210             |
| Test pressure (Bar) | NWp x 1.37                        | ---  | ---             | 287             | 287             | ---             | ---             |
| External leakage    | ≤ 15 cc/hr                        | 0  | 0               | 0               | 0               | 0               | 0               |
| Test date           | To be monitored                   | Aug. 4,<br>2004                                | Sept. 4<br>2004 | Aug. 4,<br>2004 | Sept. 4<br>2004 | Aug. 4,<br>2004 | Sept. 4<br>2004 |

2.5.2 Conclusion : The samples comply with the requirements.



# TECHNICAL REPORT

No.: 83-EIHP-33009246-100

Manufacturer : HY-LOK CORPORATION  
Type : Compression Fittings with front and back ferrules

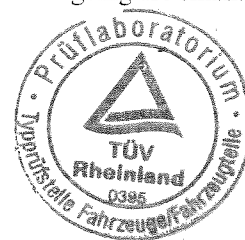
2.6 Resistance to dry heat test with respect to : Trans/WP. 29/GRPE/2004/3 Annex 8 part B2  
O-ring in accordance with

## 2.6.1 Test results

| Property                     | Status  | Method                | Sample :<br>Rubber O ring<br>code V75 | Specification of<br>manufacturer  |
|------------------------------|---|-----------------------|---------------------------------------|-----------------------------------|
| Hardness<br>[IRHD]           | - As received<br><br>- After 96 hours at 120 °C,<br>100% oxygen, 2.0 Mpa<br><br>- Change [IRHD] | ISO 48-M<br>ASTM D572 | 79<br><br>80<br><br>+1                | 75 ± 5<br><br><br>not specified   |
| Tensile<br>strength<br>[Mpa] | - As received<br><br>- After 96 hours at 120 °C,<br>100% oxygen, 2.0 Mpa<br><br>- Change [%]    | ISO 37<br>ASTM D572   | 11.9<br><br>10.7<br><br>-10           | Min 9.65<br><br><br>not specified |
| Elongation at<br>break [%]   | - As received<br><br>- After 96 hours at 120 °C,<br>100% oxygen, 2.0 Mpa<br><br>- Change [%]    | ISO 37<br>ASTM D572   | 185<br><br>190<br><br>+3              | Min. 125<br><br><br>not specified |

2.6.2 Conclusion : The test samples show no cracks or visual deterioration after exposure.

The samples as received meet the specification of the manufacturer for the measured properties. The properties after ageing in oxygen as carried out in this evaluation are not specified by the manufacturer. The changes in hardness, tensile strength and elongation after these ageing are small.



# TECHNICAL REPORT

No.: 83-EIHP-33009246-100

Manufacturer : HY-LOK CORPORATION  
Type : Compression Fittings with front and back ferrules

---

2.7 Hydrogen compatibility : Trans/WP. 29/GRPE/2004/3 Annex 8B

2.7.1 Test results

The material of the tube fittings, type 316 is confirmed to be compatible for hydrogen service by US NASA reports without performing actual test

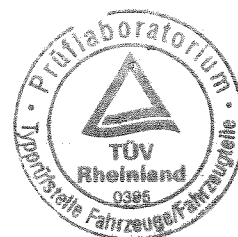
The tube fitting materials comply with the hydrogen compatibility requirements.

3 Remark concerning tested object(s) : All components as listed in the appendix 0 are covered with the tested object(s).

## 4 Statement of conformity

The test laboratory is accredited for the above mentioned tests by the accreditation body of the RDW, Netherlands.

The technical report comprises the pages 1 to 10 (including appendix 0) and shall not be reproduced except in full without the written approval of the test laboratory.



# TECHNICAL REPORT

No.: 83-EIHP-33009246-100

Manufacturer : HY-LOK CORPORATION  
Type : Compression Fittings with front and back ferrules

## Das Bauteil / The Specific Component

- |   |   |
|---|---|
| 1. Make (trade name of manufacturer)<br>Fabrikmarke                       | : Hy-Lok®<br>Hy-Lok®  |
| 2. Type<br>Typ  | : Compression Fittings with front and back ferrules<br>Doppelklemmringverschraubung |
| 3. Article<br>Art   | : Tube Fittings, Class 0<br>Fittings / Verbindungsteile Klasse 0                    |
| 4. Name and address of manufacturer<br>Name und Anschrift des Herstellers | : HY-LOK CORPORATION<br>1467-1, Songjeong-Dong, Gangseo-Gu,<br>Busan, Korea 618-270 |

Meets EIHP draft, UNIFORM PROVISIONS CONCERNING THE APPROVAL OF SPECIFIC COMPONENTS OF MOTOR VEHICLES USING COMPRESSED GASEOUS HYDROGEN Rev. 12b dated 12.10.2003, annex 08 and Trans/WP. 29/GRPE/2003/14 7-03-2003, The following program is applicable.

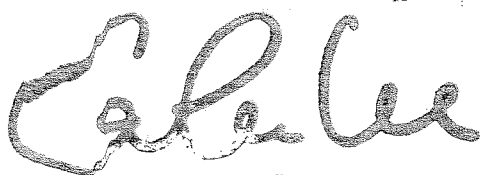
- Pressure test;
- External leakage test at different temperatures;
- Resistance to corrosion + leakage test at different temperatures;
- Resistance to dry heat test with respect to O ring;
- Connection test + leakage test at different temperatures.
- Hydrogen compatibility test

### 5. Detail information

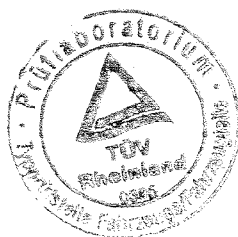
- |   |                                    |
|---|------------------------------------|
| 5.1. List of tube fittings to be covered by the testing | : Appendix 0 (page 2 & 3)          |
| 5.2. Test information                                   | : Item 1 (page 4)                  |
| 5.3. Test minutes                                       | : Item 2 (page 5, 6, 7, 8, 9 & 10) |
| 5.4. Remark concerning tested object(s)                 | : Item 3 (page 10)                 |
| 5.5. Statement of conformity                            | : Item 4 (page 10)                 |

Cologne, June 30, 2005

YBR



Dipl.-Ing. Carlos Lee



# TECHNICAL REPORT

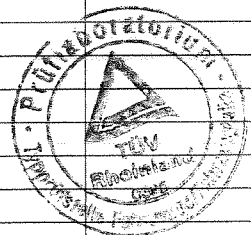
No.: 83-EIHP-33009246-100

Manufacturer : HY-LOK CORPORATION  
Type : Compression Fittings with front and back ferrules

List of tube fittings to be covered by the testing

Appendix 0

| No. | Description               | Type(Series) | Connection Size |                 | Remark |
|-----|---------------------------|--------------|-----------------|-----------------|--------|
|     |                           |              | In Size         | Metric Size(mm) |        |
| 1   | Cap for Tube End          | CCA          | 1/4"            | 6               |        |
|     |                           |              | 3/8"            | 10              |        |
|     |                           |              | 1/2"            | 12              |        |
|     |                           |              | 3/4"            | 16              |        |
|     |                           |              | 1"              | 25              |        |
| 2   | Male Connector            | CMC          | 1/4"x1/4"NPT    | 6X1/4"PT        |        |
|     |                           |              | 3/8"x3/8"NPT    | 10X3/8"PT       |        |
|     |                           |              | 1/2"x1/2"NPT    | 12X1/2"PT       |        |
|     |                           |              | 3/4"x3/4"NPT    | 16X3/4"PT       |        |
| 3   | Male Adapter              | CAM          | 1/4"x1/4"NPT    | 6X1/4"PT        |        |
|     |                           |              | 3/8"x3/8"NPT    | 10X3/8"PT       |        |
|     |                           |              | 1/2"x1/2"NPT    | 12X1/2"PT       |        |
|     |                           |              | 3/4"x3/4"NPT    | 16X3/4"PT       |        |
| 4   | Bulkhead Female Connector | CBFC         | 1/4"x1/4"NPT    | 6x1/4"PT        |        |
|     |                           |              | 3/8"x3/8"NPT    | 10x3/8"PT       |        |
|     |                           |              | 1/2"x1/2"NPT    | 12x1/2"PT       |        |
| 5   | SAE/MS Male Connector     | CSC          | 1/4"xSAE9/16    |                 |        |
|     |                           |              | 3/8"xSAE9/16    |                 |        |
|     |                           |              | 1/2"xSAE9/16    |                 |        |
| 6   | Bulkhead Union            | CBU          | 1/4"            | 6               |        |
|     |                           |              | 3/8"            | 10              |        |
|     |                           |              | 1/2"            | 12              |        |
|     |                           |              | 3/4"            | 16              |        |
| 7   | Union                     | CUA          | 1/4"            | 6               |        |
|     |                           |              | 3/8"            | 10              |        |
|     |                           |              | 1/2"            | 12              |        |
|     |                           |              | 3/4"            | 16              |        |
|     |                           |              | 1"              | 25              |        |
| 8   | Union Tee                 | CTA          | 1/4"            | 6               |        |
|     |                           |              | 3/8"            | 10              |        |
|     |                           |              | 1/2"            | 12              |        |
|     |                           |              | 3/4"            | 16              |        |
|     |                           |              | 1"              | 25              |        |
| 9   | Union Cross               | CXA          | 1/4"            | 6               |        |
|     |                           |              | 3/8"            | 10              |        |
|     |                           |              | 1/2"            | 12              |        |
|     |                           |              | 3/4"            | 16              |        |
|     |                           |              | 1"              | 25              |        |
| 10  | Union Elbow               | CLA          | 1/4"            | 6               |        |
|     |                           |              | 3/8"            | 10              |        |
|     |                           |              | 1/2"            | 12              |        |
|     |                           |              | 3/4"            | 16              |        |
|     |                           |              | 1"              | 25              |        |



# TECHNICAL REPORT

No.: 83-EIHP-33009246-100

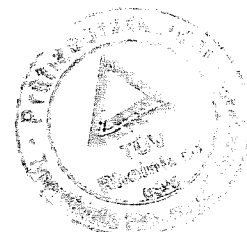
Manufacturer : HY-LOK CORPORATION  
Type : Compression Fittings with front and back ferrules

|    |                |      |              |           |  |
|----|----------------|------|--------------|-----------|--|
| 11 | Port Connector | CPC  | 1/4"         | 6         |  |
|    |                |      | 3/8"         | 10        |  |
|    |                |      | 1/2"         | 12        |  |
|    |                |      |              | 16        |  |
| 12 | Male Elbow     | CLMA | 1/4"x1/4"NPT | 6X1/4"PT  |  |
|    |                |      | 3/8"x3/8"NPT | 10X3/8"PT |  |
|    |                |      | 1/2"x1/2"NPT | 12X1/2"PT |  |
|    |                |      | 3/4"x3/4"NPT | 16X3/4"PT |  |

Note : In above table Inch sizes and metric sizes are different size each other.

So to speak inch sizes are not corresponding sizes of the metric sizes

For example No 1 Cap for tube end have 5 inch sizes and 5 metric sizes, total 10 sizes.





# TECHNICAL REPORT

No.: 83-EIHP-33009246-100

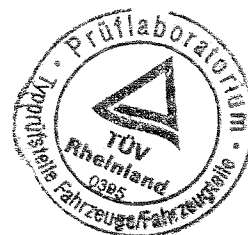
Manufacturer : HY-LOK CORPORATION  
Type : Compression Fittings with front and back ferrules

## 1 Test Information

1.1 Test object(s) :

| Sample Identification   | Tube size  | Wall thickness             | Fitting Materials   |
|---|--|----------------------------|---|
| C040512   | 6 mm   | 1.0 mm & 1.5 mm            | Barstock : ASTM A479 Type 316   |
| C040494, C040495,<br>C040496, C040497,<br>C040498 and C040513 | 3/8 inch   | 0.035 inch &<br>0.065 inch | Forging : ASTM A182 F316<br>X 5CrNiMo 17-12-2 (1.4401) /<br>316 (UNS S 31600)<br>Tubing materials : ASTM A269 / A213 Type 316/L<br>DIN 17458 (1.4401 /1.4404) |
| C040514   | 12 mm  | 1.0 mm & 2.0 mm            |   |
| C040515   | 1 inch   | 0.083 inch & 0.109<br>inch |   |
| O ring  | Rubber O-rings with code V75<br>dimension approximately 12.0 mm x 2.0 mm |                            |   |

1.2 Test date : August to September 2004 & June 2005  
1.3 Test site : GASTEC Certification BV, the Netherlands  
1.4 Remark : The results of the test refer exclusively to the object(s)  
mentioned under point 1.1 of this report.



# TECHNICAL REPORT

No.: 83-EIHP-33009246-100

Manufacturer : HY-LOK CORPORATION  
Type : Compression Fittings with front and back ferrules

## 2 Test minutes

2.1 Test facilities : The test equipment used was in compliance with the requirements of the regulation and / or the standard.

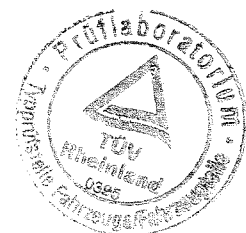
2.2 External leakage test including high & low temperature in accordance with : Trans/WP. 29/GRPE/2003/14 Annex 8B

### 2.2.1 Test results

| Test results        | Requirement     | Sample no. C040512, C040513, C040514 & C040515 |              |              |              |              |              |
|---------------------|-----------------|--|--------------|--------------|--------------|--------------|--------------|
| Test temperature    | ---             | Room temperature                               |              | 85/105/120°C |              | - 40°C       |              |
| Moment of test      | Corrosion       | Before   | After        | Before       | After        | Before       | After        |
| Test pressure (Bar) | 0.02 x NWP      | 4.2  | 4.2          | 4.2          | 4.2          | 4.2          | 4.2          |
| External leakage    | ≤ 15 cc/hr      | 0  | 0            | 0            | 0            | 0            | 0            |
| Test pressure (Bar) | NWP             | 210  | 210          | ---          | ---          | 210          | 210          |
| Test pressure (Bar) | NWP x 1.37      | ---  | ---          | 287          | 287          | ---          | ---          |
| External leakage    | ≤ 15 cc/hr      | 0  | 0            | 0            | 0            | 0            | 0            |
| Test date           | To be monitored | Aug. 4, 2004                                   | Sept. 4 2004 | Aug. 4, 2004 | Sept. 4 2004 | Aug. 4, 2004 | Sept. 4 2004 |

\* NWP=Normal working pressure (210 bar)

2.2.2 Conclusion : The samples comply with the requirements.



# TECHNICAL REPORT

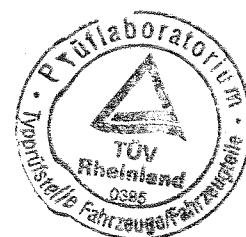
No.: 83-EIHP-33009246-100

Manufacturer : HY-LOK CORPORATION  
Type : Compression Fittings with front and back ferrules

2.3 Corrosion test (Salt spray) in accordance with : Trans/WP. 29/GRPE/2003/14 Annex 8B

## 2.3.1 Test results

|  |                            |  |
|--|----------------------------|--|
| Test results   | Requirement                | Sample no. C040512, C040513, C040514 & C040515 |
| Date & time starting the test                        | To be monitored            | August 2004                                    |
| Date & time stopping the test                        | To be monitored            | September 2004                                 |
| Salt spray testing time                              | 144 hours                  | 144  |
| Ambient temperature during the test                  | $35 \pm 2^{\circ}\text{C}$ | 35   |
| Store time at room temperature                       | 0.5 – 1.0 hour             | 1  |
| Tests to be performed after the endurance test are : |                            |  |
| External leakage test                                | ---                        | See above 2.2                                  |
| Internal leakage test                                | ---                        | ---  |



# TECHNICAL REPORT

No.: 83-EIHP-33009246-100

Manufacturer : HY-LOK CORPORATION  
Type : Compression Fittings with front and back ferrules

2.4 Overpressure test in accordance with : Trans/WP. 29/GRPE/2003/14 Annex 8B

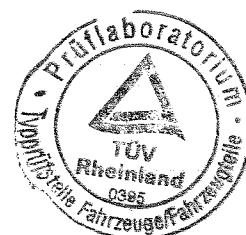
## 2.4.1 Test results

| Test results         | Requirement     | Sample no. C040512, C040513, C040514 & C040515 |       |              |       |              |       |
|----------------------|-----------------|--|-------|--------------|-------|--------------|-------|
| Moment of test       | ---             | Before   | After | Before       | After | Before       | After |
| Test pressure (Bar)  | 1.5 x MAWP      | 315  | N/A   | 315          | N/A   | 315          | N/A   |
| Test time            | $\geq 3$ min    | 5  | N/A   | 5            | N/A   | 5            | N/A   |
| Rupture              | No              | No   | N/A   | No           | N/A   | No           | N/A   |
| Permanent distortion | No              | No   | N/A   | No           | N/A   | No           | N/A   |
| Test pressure (Bar)  | 3.0 x MAWP      | 630  | N/A   | 630          | N/A   | 630          | N/A   |
| Test time            | $\geq 3$ min    | 5  | N/A   | 5            | N/A   | 5            | N/A   |
| Rupture              | No              | No   | N/A   | No           | N/A   | No           | N/A   |
| Permanent distortion | No              | No   | N/A   | No           | N/A   | No           | N/A   |
| Test date            | To be monitored | Sep. 4, 2004                                   | N/A   | Sep. 4, 2004 | N/A   | Sep. 4, 2004 | N/A   |

\* N/A : Not applicable

\* MAWP : maximum allowable working pressure

2.4.2 Conclusion : The samples comply with the requirements.



# TECHNICAL REPORT

No.: 83-EIHP-33009246-100

Manufacturer : HY-LOK CORPORATION  
Type : Compression Fittings with front and back ferrules

2.5 Endurance test including high & low temperature : Trans/WP. 29/GRPE/2003/14 Annex 8B (Leak tightness)  
in accordance with

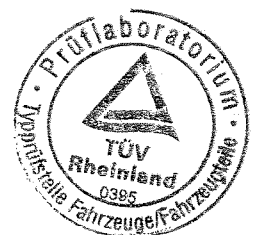
Draft ECE regulation revision 12b dated 12-10-2003  
(Endurance test)

## 2.5.1 Test results

| Test results        | Requirement                       | Sample no. C040512, C040513, C040514 & C040515 |                 |                 |                 |                 |                 |
|---------------------|-----------------------------------|--|-----------------|-----------------|-----------------|-----------------|-----------------|
| Test temperature    | ---                               | Room temperature                               |                 | 85/105/120°C    |                 | - 40°C          |                 |
| Moment of test      | 25 connections/<br>disconnections | Before   | After           | Before          | After           | Before          | After           |
| Test pressure (Bar) | 0.02 x NWp                        | 4.2  | 4.2             | 4.2             | 4.2             | 4.2             | 4.2             |
| External leakage    | ≤ 15 cc/hr                        | 0  | 0               | 0               | 0               | 0               | 0               |
| Test pressure (Bar) | NWp                               | 210  | 210             | ---             | ---             | 210             | 210             |
| Test pressure (Bar) | NWp x 1.37                        | ---  | ---             | 287             | 287             | ---             | ---             |
| External leakage    | ≤ 15 cc/hr                        | 0  | 0               | 0               | 0               | 0               | 0               |
| Test date           | To be monitored                   | Aug. 4,<br>2004                                | Sept. 4<br>2004 | Aug. 4,<br>2004 | Sept. 4<br>2004 | Aug. 4,<br>2004 | Sept. 4<br>2004 |

## 2.5.2 Conclusion

: The samples comply with the requirements.



# TECHNICAL REPORT

No.: 83-EIHP-33009246-100

Manufacturer : HY-LOK CORPORATION  
Type : Compression Fittings with front and back ferrules

2.6 Resistance to dry heat test with respect to : Trans/WP. 29/GRPE/2004/3 Annex 8 part B2  
O-ring in accordance with

## 2.6.1 Test results

| Property                     | Status  | Method                | Sample :<br>Rubber O ring<br>code V75 | Specification of<br>manufacturer      |
|------------------------------|---|-----------------------|---------------------------------------|---------------------------------------|
| Hardness<br>[IRHD]           | - As received<br><br>- After 96 hours at 120 °C,<br>100% oxygen, 2.0 Mpa<br><br>- Change [IRHD] | ISO 48-M<br>ASTM D572 | 79<br><br>80<br><br>+1                | 75 ± 5<br><br><br><br>not specified   |
| Tensile<br>strength<br>[Mpa] | - As received<br><br>- After 96 hours at 120 °C,<br>100% oxygen, 2.0 Mpa<br><br>- Change [%]    | ISO 37<br>ASTM D572   | 11.9<br><br>10.7<br><br>-10           | Min 9.65<br><br><br><br>not specified |
| Elongation at<br>break [%]   | - As received<br><br>- After 96 hours at 120 °C,<br>100% oxygen, 2.0 Mpa<br><br>- Change [%]    | ISO 37<br>ASTM D572   | 185<br><br>190<br><br>+3              | Min. 125<br><br><br><br>not specified |

2.6.2 Conclusion : The test samples show no cracks or visual deterioration after exposure.

The samples as received meet the specification of the manufacturer for the measured properties. The properties after ageing in oxygen as carried out in this evaluation are not specified by the manufacturer. The changes in hardness, tensile strength and elongation after these ageing are small.

