

### **DFX - Production Readiness Review (PRR)**

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3<sup>rd</sup> March 2020

#### DFX PRR (Proto) – 03 MAR 2020

### **DFX - Production Readiness Review**

### **Contents**

- 1. General quality plan
- 2. Manufacturing and Inspection Plan
- 3. Procedures (fabrication and inspection)
- 4. Component procurement plan SOTON
- 5. Production schedule and associated resources



### **General quality plan**

The DFX prototype quality plan should filter down through the following steps and collect/store all required documentation:

#### 1. Design phase

The design phase shall lead to the production of all required documentation and terminates upon approval by CERN.

#### 2. Manufacturing preparation phase

The manufacturing preparation phase shall lead to the production of all required documentation and terminates upon approval by CERN. Note: The manufacturing shall not start without CERN's acceptance based on a Production Readiness Review.

#### 3. Manufacturing preparation phase

The manufacturing phase shall lead to the manufacture of all the DFX prototype components, and production of all required documentation

#### 4. Assembly and qualification phase

The assembly and qualification phase shall lead to the assembly of the DFX prototype and production of all required documentation.

### **5.** Archiving All documentation shall be uploaded to MTF (Manufacturing & Test Folder).

#### 6. Delivery

CERN's approval shall release the DFX prototype for delivery to CERN.

#### 7. Acceptance

Acceptance of the DFX prototype shall be subject to the successful completion of the tests by the supplier and the submission to CERN of all compliant tests results or other certificates



### **General quality plan information**

- 1. SOTON and CERN team have submitted the General Quality Plan (DRAFT) document as part of the HLC Project and setup of the MTF
- 2. SOTON defined the definition "quality team" and accepted the rules and processes that must be undertaken and followed as part of the HLC project
- 3. SOTON have selected to work with LTi Metaltech (UK precision fabricators) to manufacture DFX "prototype" and beyond...
  - LTi Metaltech are ISO 9001,14001 & 18001 accredited
  - LTi Metaltech use **British Engineering Services** to validate vessel design and testing protocol, welding procedures, weld maps, weld NDT and weld inspection



### **Quality plan working template**

|                                |                             | Desigr | 1                                |                           | Proc          | urement               |                            |                         |                                |                       | Manu                   | Ifacturing  | , assembly             | and qual             | ification      |                 |                     |          |           |                  | QA           |             |
|--------------------------------|-----------------------------|--------|----------------------------------|---------------------------|---------------|-----------------------|----------------------------|-------------------------|--------------------------------|-----------------------|------------------------|-------------|------------------------|----------------------|----------------|-----------------|---------------------|----------|-----------|------------------|--------------|-------------|
|                                | Design report               | S      | afety file                       |                           |               |                       |                            |                         |                                |                       | We                     | lding       |                        | Weld inspe           | ection         |                 | Leak                | test     | Cleaning  |                  | Proce        | edures      |
|                                | Thermo-mech.<br>Fluid mech. |        | Pressure relief<br>device design | Manufacturing<br>drawings | CE<br>certif. |                       | Pressure test<br>procedure | Material<br>certificate | Manuf. &<br>Inspection<br>Plan | Dimensional<br>report | Welder                 | Procedure   | NDT personel           | Visual<br>inspection | X-ray<br>proc. | X-ray<br>result | Procedure           | Operator | Procedure | MTF<br>archiving | Installation | maintenance |
| Standard                       | EN13445-3<br>EN13458-2      | NA     | ISO21013-3<br>EN4126-6           | ISO-GPS                   | PED           | EN13445<br>EN14917+A1 | EN13458-2                  | EN10028<br>HL-LHC_QA    | NA                             | NA                    | ISO 9606-1<br>ISO14732 | ISO 15614-1 | ISO 9712<br>NDT level2 | ISO 17637            | ISO 17636      |                 | EN1779A1<br>EN13185 |          | EN12300   | NA               | NA           | NA          |
| Qualification by notified body |                             |        |                                  |                           | (X)           | (X)                   |                            |                         |                                |                       | x                      | х           | x                      |                      |                |                 |                     | x        |           |                  |              |             |
| Components                     |                             |        |                                  |                           |               |                       |                            |                         |                                |                       |                        |             |                        |                      |                |                 |                     |          |           |                  |              |             |
| Vacuum vessel                  | x                           |        | x                                | x                         |               |                       |                            | x                       | x                              | x                     | x                      | x           | x                      | x                    | х              | x               | х                   | x        | x         | х                |              | х           |
| Bellows vacuum                 |                             |        |                                  | х                         |               | x                     |                            | х                       |                                | x                     |                        |             | (X)                    | (X)                  | (X)            | (X)             | х                   | x        | x         | х                |              |             |
| Helium vessels                 | x                           |        | x                                | х                         | х             | x                     | x                          | x                       | x                              | x                     | x                      | x           | x                      | x                    | х              | x               | х                   | x        | х         | х                |              | х           |
| Bellows helium                 |                             | X      |                                  | х                         | х             | x                     | х                          | x                       |                                | x                     | х                      | х           | x                      | x                    | (X)            | (X)             | х                   | x        | х         | х                | x            |             |
| MLI                            |                             |        |                                  | х                         |               |                       |                            | x                       |                                | x                     |                        |             |                        |                      |                |                 |                     |          |           | (X)              |              |             |
| Structural supports            | x                           |        |                                  | х                         |               |                       |                            | x                       |                                | x                     |                        |             |                        |                      |                |                 |                     |          | x         | (X)              |              |             |



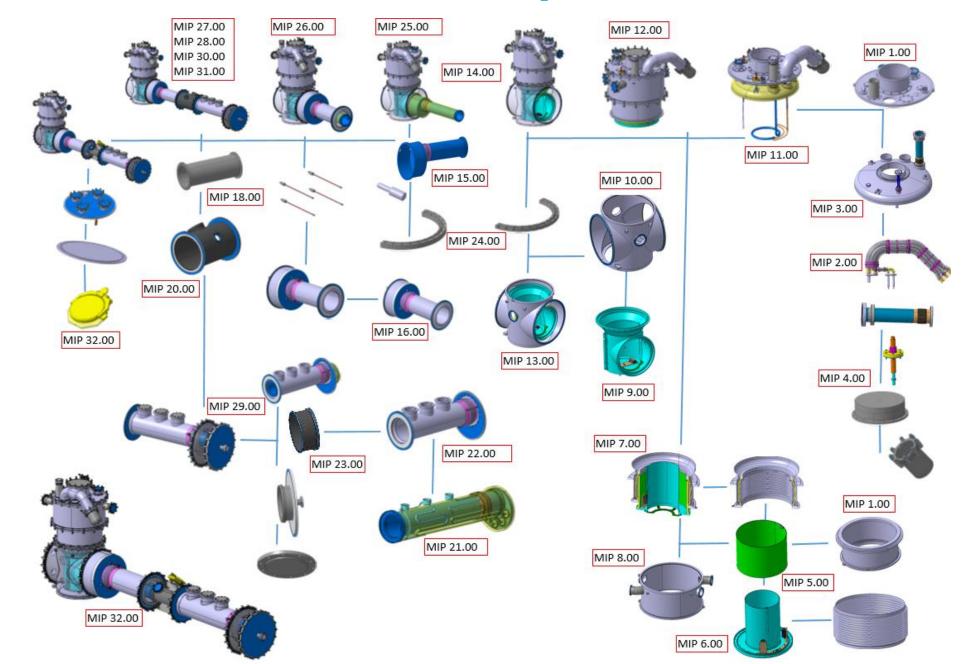
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### **Manufacturing and Inspection Plan (MIP)**



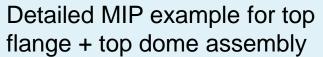
### **MIP** map

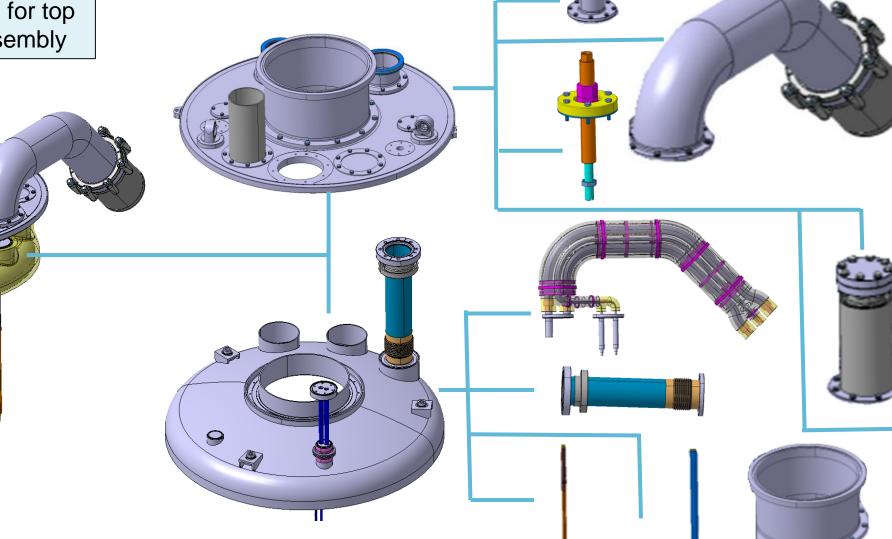
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| KEY  | Task type   |  |   |                         |                       |                        |                         |                      |                   |                 |                         |                       |                     |   |
|--|---|--|---|-------------------------|-----------------------|------------------------|-------------------------|----------------------|-------------------|-----------------|-------------------------|-----------------------|---------------------|---|
|  | Activity title  |  |   |                         |                       |                        |                         |                      |                   |                 |                         |                       |                     |   |
|  | Metrology   |  |   |                         |                       |                        |                         |                      |                   |                 |                         |                       |                     |   |
|  | Machining/fabrication/procure   |  |   |                         |                       |                        |                         |                      |                   |                 |                         |                       |                     |   |
|  | Welding   |  |   |                         |                       |                        |                         |                      |                   |                 |                         |                       |                     |   |
|  | X-ray report  |  |   |                         |                       |                        |                         |                      |                   |                 |                         |                       |                     |   |
|  | Leak detection  |  |   |                         |                       |                        |                         |                      |                   |                 |                         |                       |                     |   |
|  | Cleaning  |  |   |                         |                       |                        |                         |                      |                   |                 |                         |                       |                     |   |
|  | MLI application   |  |   |                         |                       |                        |                         |                      |                   |                 |                         |                       |                     |   |
|  | Assembly  |  |   |                         |                       |                        |                         |                      |                   |                 |                         |                       |                     |   |
|  |   |  |   |                         |                       |                        |                         |                      |                   |                 |                         |                       |                     |   |
|  |   |  | HL-HLC  | : QUALIT)               | ( - Ma                | nufac                  | turing a                | and In               | spection          | Plan for        | DFX C                   | ryostat               |                     |   |
| Prepared   | by: W. Bailey, Y.Yang   |  |   |                         |                       |                        |                         |                      |                   |                 |                         |                       |                     |   |
| Date: 20-0   | 02-2020   | _  | F   | roject: HL-l            | LHC                   |                        |                         |                      | on                |                 |                         |                       |                     |   |
| Verfied by   | :   |  |   | -                       |                       |                        |                         |                      |                   |                 |                         |                       |                     |   |
| Date:  |   |  |   |                         |                       |                        |                         |                      |                   |                 |                         |                       |                     |   |
| Approved   | by:   | -  | Wo  | rk Pacakge:             | WP6a                  |                        |                         |                      |                   |                 |                         |                       |                     |   |
| Date:  | al.   | _  |   | in rucange.             |                       |                        |                         |                      |                   | ł               |                         |                       |                     |   |
|  | Activity  | DWG ID Number  |   |                         |                       |                        | Appl. Standa            | rds/Procedu          |                   | Supplier Name   |                         |                       |                     |   |
|  |   |  | Material  | Metrology               |                       | Welding                |                         | Cleaning             | w                 | eld Inspection  | ction                   |                       |                     |   |
|  |   |  |   | 1                       |                       |                        |                         |                      |                   |                 |                         |                       |                     |   |
|  |   |  | Material cert                                   | Dimensional note        | Welder                | Procedure              | NDT personel            | Procedure            | Visual inspection | X-ray procedure | X-ray result            | Procedure             | Operator            |   |
|  |   | 150.005  | Material cert                                   | Dimensional note        | Welder                | Procedure              | NDT personel            |                      | Visual inspection |                 |                         | Procedure             | Operator            |   |
|  |   | ISO GPS  | Material cert<br>EN10028                        | Dimensional note<br>n/a | Welder<br>ISO9606-1   | Procedure<br>ISO9606-2 | NDT personel<br>ISO9712 | Procedure<br>EN12300 | Visual inspection | X-ray procedure | X-ray result<br>ISO5817 | Procedure<br>EN1779A1 | Operator<br>ISO9712 |   |
|  |   | ISO GPS  |   |                         |                       |                        |                         |                      |                   |                 |                         |                       | -                   |   |
| <u>1.00</u>  | Manufacturing of top flange   | ISO GPS  |   |                         | ISO9606-1             |                        | ISO9712                 |                      |                   |                 | ISO5817                 | EN1779A1              | ISO9712             |   |
| <u>1.00</u><br>1.01  | Manufacturing of top flange<br>Machine top flange   | <u></u>  |   |                         | ISO9606-1             |                        | ISO9712                 |                      |                   |                 | ISO5817                 | EN1779A1              | ISO9712             | LTi Metaltech   |
|  |   | LHCDFX_0129  | EN10028   |                         | ISO9606-1             |                        | ISO9712                 |                      |                   |                 | ISO5817                 | EN1779A1              | ISO9712             | LTi Metaltech<br>LTi Metaltech  |
| 1.01   | Machine top flange  | LHCDFX_0129<br>LHCDFX_0125   | EN10028   |                         | ISO9606-1             |                        | ISO9712                 |                      |                   |                 | ISO5817                 | EN1779A1              | ISO9712             |   |
| 1.01<br>1.02   | Machine top flange Machine SCLink "hat" components  | LHCDFX_0129<br>LHCDFX_0125<br>LHCDFX_0073  | EN10028   |                         | ISO9606-1             |                        | ISO9712                 |                      |                   |                 | ISO5817                 | EN1779A1              | ISO9712             | LTi Metaltech   |
| 1.01<br>1.02<br>1.03   | Machine top flange<br>Machine SCLink "hat" components<br>Machine blank flanges  | LHCDFX_0129<br>LHCDFX_0125<br>LHCDFX_0073<br>LHCDFX_0096   | EN10028   |                         | ISO9606-1             |                        | ISO9712                 |                      |                   |                 | ISO5817                 | EN1779A1              | ISO9712             | LTi Metaltech<br>LTi Metaltech  |
| 1.01<br>1.02<br>1.03<br>1.04   | Machine top flange<br>Machine SCLink "hat" components<br>Machine blank flanges<br>Machine burst disc components   | LHCDFX_0129<br>LHCDFX_0125<br>LHCDFX_0073<br>LHCDFX_0096<br>LHCDFX_0100  | EN10028   |                         | ISO9606-1             |                        | ISO9712                 |                      |                   |                 | ISO5817                 | EN1779A1              | ISO9712             | LTi Metaltech<br>LTi Metaltech<br>LTi Metaltech   |
| 1.01<br>1.02<br>1.03<br>1.04<br>1.05   | Machine top flange<br>Machine SCLink "hat" components<br>Machine blank flanges<br>Machine burst disc components<br>Machine dust protection flange   | LHCDFX_0129<br>LHCDFX_0125<br>LHCDFX_0073<br>LHCDFX_0096<br>LHCDFX_0100<br>LHCDFX_0098   | EN10028   |                         | ISO9606-1             |                        | ISO9712                 |                      |                   |                 | ISO5817                 | EN1779A1              | ISO9712             | LTi Metaltech<br>LTi Metaltech<br>LTi Metaltech<br>LTi Metaltech  |
| 1.01<br>1.02<br>1.03<br>1.04<br>1.05<br>1.06   | Machine top flange         Machine SCLink "hat" components         Machine blank flanges         Machine burst disc components         Machine dust protection flange         Machine VV mounting flange blind  | LHCDFX_0129<br>LHCDFX_0125<br>LHCDFX_0073<br>LHCDFX_0096<br>LHCDFX_0096<br>LHCDFX_0098<br>LHCDFX_0099  | EN10028<br>X<br>X<br>X<br>X<br>X<br>X<br>X<br>X |                         | ISO9606-1             |                        | ISO9712                 |                      |                   |                 | ISO5817                 | EN1779A1              | ISO9712             | LTi Metaltech<br>LTi Metaltech<br>LTi Metaltech<br>LTi Metaltech<br>LTi Metaltech   |
| 1.01<br>1.02<br>1.03<br>1.04<br>1.05<br>1.06<br>1.07   | Machine top flange         Machine SCLink "hat" components         Machine blank flanges         Machine burst disc components         Machine dust protection flange         Machine VV mounting flange blind         Machine fisheye supports components  | LHCDFX_0129<br>LHCDFX_0125<br>LHCDFX_0073<br>LHCDFX_0096<br>LHCDFX_0096<br>LHCDFX_0098<br>LHCDFX_0099<br>LHCDFX_0029<br>LHCDFX_0126                | EN10028   |                         | ISO9606-1             |                        | ISO9712                 |                      |                   |                 | ISO5817                 | EN1779A1              | ISO9712             | LTi Metaltech<br>LTi Metaltech<br>LTi Metaltech<br>LTi Metaltech<br>LTi Metaltech<br>LTi Metaltech  |
| 1.01<br>1.02<br>1.03<br>1.04<br>1.05<br>1.06<br>1.07<br>1.08   | Machine top flange         Machine SCLink "hat" components         Machine blank flanges         Machine burst disc components         Machine VV mounting flange blind         Machine fisheye supports components         Machine level gauge VV lower components   | LHCDFX_0129<br>LHCDFX_0125<br>LHCDFX_0073<br>LHCDFX_0096<br>LHCDFX_0100<br>LHCDFX_0098<br>LHCDFX_0099<br>LHCDFX_0026<br>LHCDFX_0118                | EN10028   |                         | ISO9606-1             |                        | ISO9712                 |                      |                   |                 | ISO5817                 | EN1779A1              | ISO9712             | LTi Metaltech<br>LTi Metaltech<br>LTi Metaltech<br>LTi Metaltech<br>LTi Metaltech<br>LTi Metaltech<br>LTi Metaltech   |
| 1.01<br>1.02<br>1.03<br>1.04<br>1.05<br>1.06<br>1.07<br>1.08<br>1.09   | Machine top flange         Machine SCLink "hat" components         Machine blank flanges         Machine burst disc components         Machine dust protection flange         Machine flanges blind         Machine fisheye supports components         Machine level gauge VV lower components         Machine level gauge VV upper components   | LHCDFX_0129<br>LHCDFX_0125<br>LHCDFX_0073<br>LHCDFX_0096<br>LHCDFX_0100<br>LHCDFX_0099<br>LHCDFX_0099<br>LHCDFX_0126<br>LHCDFX_0118<br>LHCDFX_0120 | EN10028   |                         | ISO9606-1             |                        | ISO9712                 |                      |                   |                 | ISO5817                 | EN1779A1              | ISO9712             | LTi Metaltech<br>LTi Metaltech<br>LTi Metaltech<br>LTi Metaltech<br>LTi Metaltech<br>LTi Metaltech<br>LTi Metaltech<br>LTi Metaltech  |
| 1.01<br>1.02<br>1.03<br>1.04<br>1.05<br>1.06<br>1.07<br>1.08<br>1.09<br>1.10   | Machine top flange         Machine SCLink "hat" components         Machine blank flanges         Machine burst disc components         Machine dust protection flange         Machine fisheye supports components         Machine level gauge VV lower components         Machine level gauge VV upper components         Machine level gauge VV upper components         Machine level gauge VV upper components   | LHCDFX_0129<br>LHCDFX_0073<br>LHCDFX_0096<br>LHCDFX_0096<br>LHCDFX_0098<br>LHCDFX_0098<br>LHCDFX_0126<br>LHCDFX_0118<br>LHCDFX_0118<br>LHCDFX_0110 | EN10028   |                         | ISO9606-1<br>ISO14732 | ISO9606-2              | ISO9712<br>NDT Level 2  |                      | ISO17637          | ISO17636        | ISO5817                 | EN1779A1              | ISO9712             | LTi Metaltech<br>LTi Metaltech<br>LTi Metaltech<br>LTi Metaltech<br>LTi Metaltech<br>LTi Metaltech<br>LTi Metaltech<br>LTi Metaltech<br>LTi Metaltech   |
| 1.01<br>1.02<br>1.03<br>1.04<br>1.05<br>1.06<br>1.07<br>1.08<br>1.09<br>1.10<br>1.11   | Machine top flange         Machine SCLink "hat" components         Machine blank flanges         Machine burst disc components         Machine dust protection flange         Machine VV mounting flange blind         Machine level gauge VV lower components         Machine level gauge VV upper components         Machine Vv saftey port components  | LHCDFX_0129<br>LHCDFX_0073<br>LHCDFX_0096<br>LHCDFX_0096<br>LHCDFX_0098<br>LHCDFX_0098<br>LHCDFX_0126<br>LHCDFX_0118<br>LHCDFX_0118<br>LHCDFX_0110 | EN10028   | n/a                     | ISO9606-1<br>ISO14732 | ISO9606-2              | ISO9712<br>NDT Level 2  |                      | ISO17637          | ISO17636        | ISO5817                 | EN1779A1              | ISO9712             | LTi Metaltech<br>LTi Metaltech<br>LTi Metaltech<br>LTi Metaltech<br>LTi Metaltech<br>LTi Metaltech<br>LTi Metaltech<br>LTi Metaltech<br>LTi Metaltech<br>LTi Metaltech  |
| 1.01<br>1.02<br>1.03<br>1.04<br>1.05<br>1.06<br>1.07<br>1.08<br>1.09<br>1.10<br>1.11<br>1.12   | Machine top flange         Machine SCLink "hat" components         Machine blank flanges         Machine burst disc components         Machine dust protection flange         Machine VV mounting flange blind         Machine Isheye supports components         Machine level gauge VV lower components         Machine level gauge VV upper components         Machine Vv saftey yalve (SV) port components         Machine VV saftey port components         Check dimensions, tolerances and surface finish of completed components  | LHCDFX_0129<br>LHCDFX_0073<br>LHCDFX_0096<br>LHCDFX_0096<br>LHCDFX_0098<br>LHCDFX_0098<br>LHCDFX_0126<br>LHCDFX_0118<br>LHCDFX_0118<br>LHCDFX_0110 | EN10028   | n/a                     | ISO9606-1<br>ISO14732 | ISO9606-2              | ISO9712<br>NDT Level 2  | EN12300              | ISO17637          | ISO17636        | ISO5817                 | EN1779A1              | ISO9712             | LTi Metaltech<br>LTi Metaltech<br>LTi Metaltech<br>LTi Metaltech<br>LTi Metaltech<br>LTi Metaltech<br>LTi Metaltech<br>LTi Metaltech<br>LTi Metaltech<br>LTi Metaltech  |
| 1.01<br>1.02<br>1.03<br>1.04<br>1.05<br>1.06<br>1.07<br>1.08<br>1.09<br>1.10<br>1.11<br>1.12<br>1.13   | Machine top flange         Machine SCLink "hat" components         Machine blank flanges         Machine burst disc components         Machine VV mounting flange blind         Machine level gauge VV lower components         Machine level gauge VV lower components         Machine/Vr saftey port components         Machine/VV saftey port components         Machine/VV saftey port components         Check dimensions, tolerances and surface finish of completed components         Clean all fabricated parts  | LHCDFX_0129<br>LHCDFX_0073<br>LHCDFX_0096<br>LHCDFX_0096<br>LHCDFX_0098<br>LHCDFX_0098<br>LHCDFX_0126<br>LHCDFX_0118<br>LHCDFX_0118<br>LHCDFX_0110 | EN10028   | n/a                     | ISO9606-1<br>ISO14732 | ISO9606-2              | ISO9712<br>NDT Level 2  | EN12300              | ISO17637          | ISO17636        | ISO5817                 | EN1779A1              | ISO9712             | LTi Metaltech<br>LTi Metaltech   |
| 1.01<br>1.02<br>1.03<br>1.04<br>1.05<br>1.06<br>1.07<br>1.08<br>1.09<br>1.09<br>1.11<br>1.11<br>1.12<br>1.13<br>1.14   | Machine top flange         Machine SCLink "hat" components         Machine blank flanges         Machine blank flanges         Machine burst disc components         Machine VV mounting flange blind         Machine level gauge VV lower components         Machine level gauge VV lower components         Machine Iver aguage VV upper components         Machine VV saftey port components         Check dimensions, tolerances and surface finish of completed components         Clean all fabricated parts         Weld burst disc tube to ring flange to complete assembly                       | LHCDFX_0129<br>LHCDFX_0073<br>LHCDFX_0096<br>LHCDFX_0096<br>LHCDFX_0098<br>LHCDFX_0098<br>LHCDFX_0126<br>LHCDFX_0118<br>LHCDFX_0118<br>LHCDFX_0110 | EN10028   | n/a                     | ISO9606-1<br>ISO14732 | ISO9606-2              | ISO9712<br>NDT Level 2  | EN12300              | ISO17637          | ISO17636        | ISO5817                 | EN1779A1              | ISO9712             | LTi Metaltech<br>LTi Metaltech  |
| 1.01<br>1.02<br>1.03<br>1.04<br>1.05<br>1.06<br>1.07<br>1.08<br>1.09<br>1.10<br>1.11<br>1.12<br>1.13<br>1.14<br>1.15   | Machine top flange         Machine SCLink "hat" components         Machine blank flanges         Machine burst disc components         Machine dust protection flange         Machine fisheye supports components         Machine fisheye supports components         Machine level gauge VV lower components         Machine level gauge VV upper components         Machine/procure safety valve (SV) port components         Machine VV saftey port components         Check dimensions, tolerances and surface finish of completed components         Clean all fabricated parts         Weld burst disc tube to ring flange to complete assembly         Check perpendicularity of burst disc tube with flange                                       | LHCDFX_0129<br>LHCDFX_0073<br>LHCDFX_0096<br>LHCDFX_0096<br>LHCDFX_0098<br>LHCDFX_0098<br>LHCDFX_0126<br>LHCDFX_0118<br>LHCDFX_0118<br>LHCDFX_0110 | EN10028   | n/a                     | ISO9606-1<br>ISO14732 | ISO9606-2              | ISO9712<br>NDT Level 2  | EN12300              | ISO17637          | ISO17636        | ISO5817                 | EN1779A1              | ISO9712             | LTi Metaltech<br>LTi Metaltech  |
| 1.01<br>1.02<br>1.03<br>1.04<br>1.05<br>1.06<br>1.06<br>1.07<br>1.08<br>1.09<br>1.10<br>1.11<br>1.12<br>1.13<br>1.14<br>1.15   | Machine top flange         Machine SCLink "hat" components         Machine blank flanges         Machine burst disc components         Machine dust protection flange         Machine fisheye supports components         Machine level gauge VV lower components         Machine level gauge VV lower components         Machine level gauge VV upper components         Machine/procure safety valve (SV) port components         Machine VV saftey port components         Check dimensions, tolerances and surface finish of completed components         Clean all fabricated parts         Weld burst disc tube to ring flange to complete assembly         Check perpendicularity of burst disc tube with flange         Clean burst disc assembly | LHCDFX_0129<br>LHCDFX_0073<br>LHCDFX_0096<br>LHCDFX_0096<br>LHCDFX_0098<br>LHCDFX_0098<br>LHCDFX_0126<br>LHCDFX_0118<br>LHCDFX_0118<br>LHCDFX_0110 | EN10028   | n/a                     | ISO9606-1<br>ISO14732 | ISO9606-2              | ISO9712<br>NDT Level 2  | EN12300              | ISO17637          | ISO17636        | ISO5817                 | EN1779A1              | ISO9712<br>Level 2  | LTi Metaltech<br>LTi Metaltech   |
| 1.01<br>1.02<br>1.03<br>1.04<br>1.05<br>1.06<br>1.07<br>1.08<br>1.09<br>1.10<br>1.11<br>1.12<br>1.13<br>1.13<br>1.15<br>1.16<br>1.17   | Machine top flange         Machine SCLink "hat" components         Machine blank flanges         Machine burst disc components         Machine dust protection flange         Machine fisheye supports components         Machine level gauge VV lower components         Machine level gauge VV lower components         Machine level gauge VV upper components         Machine VV saftey port components         Machine VV saftey port components         Check dimensions, tolerances and surface finish of completed components         Clean all fabricated parts         Weld burst disc tube to ring flange to complete assembly         Clean burst disc assembly         Weld inspection   | LHCDFX_0129<br>LHCDFX_0073<br>LHCDFX_0096<br>LHCDFX_0096<br>LHCDFX_0098<br>LHCDFX_0098<br>LHCDFX_0126<br>LHCDFX_0118<br>LHCDFX_0118<br>LHCDFX_0110 | EN10028   | n/a                     | ISO9606-1<br>ISO14732 | ISO9606-2              | ISO9712<br>NDT Level 2  | EN12300              | ISO17637          | ISO17636        | ISO5817                 | EN1779A1<br>EN13185   | ISO9712<br>Level 2  | LTi Metaltech<br>LTi Metaltech                  |
| 1.01           1.02           1.03           1.04           1.05           1.06           1.07           1.08           1.09           1.11           1.12           1.13           1.14           1.15           1.16           1.17           1.18 | Machine top flange         Machine SCLink "hat" components         Machine blank flanges         Machine burst disc components         Machine dust protection flange         Machine fisheye supports components         Machine level gauge VV lower components         Machine level gauge VV upper components         Machine level gauge VV upper components         Machine VV saftey port components         Machine VV saftey port components         Check dimensions, tolerances and surface finish of completed components         Clean all fabricated parts         Weld burst disc tube to ring flange to complete assembly         Clean burst disc sasembly         Weld inspection         Perform leak detection                        | LHCDFX_0129<br>LHCDFX_0073<br>LHCDFX_0096<br>LHCDFX_0096<br>LHCDFX_0098<br>LHCDFX_0098<br>LHCDFX_0126<br>LHCDFX_0118<br>LHCDFX_0118<br>LHCDFX_0110 | EN10028   | n/a                     | ISO9606-1<br>ISO14732 | ISO9606-2              | ISO9712<br>NDT Level 2  | EN12300              | ISO17637          | ISO17636        | ISO5817                 | EN1779A1<br>EN13185   | ISO9712<br>Level 2  | LTi Metaltech<br>LTi Metaltech |



#### HL-HLC: QUALITY - Manufacturing and Inspection Plan for DFX Cryostat

| Prepared<br>Date: 20-0<br>Verfied by |   | -                          |             | Р             | roject: HL-                           | LHC       |            |              |  | Su                 | upplier: Un     | ni of Sou      | uthamap             | ton      |                |
|--------------------------------------|---|----------------------------|-------------|---------------|---------------------------------------|-----------|------------|--------------|--|--------------------|-----------------|----------------|---------------------|----------|----------------|
| Date:                                |   |                            |             |               |                                       |           |            | ;            |  |                    |                 |                |                     |          |                |
| Approved                             | bv:   | 1                          |             | Wor           | rk Pacakge:                           | : WP6a    |            | 1            | 1  |                    | Cli             | ient: CEF      | RN                  |          |                |
|                                      |   | -                          |             |               | KT deange.                            |           |            | ,            | 1  |                    |                 | 01101-02.      |                     |          | 1              |
| Date:                                | ·   | +                          | —           |               |                                       |           |            |              | <u> </u>                                     |                    |                 |                |                     |          | T              |
| No.                                  | Activity  | DWG ID Number              |             |               |                                       |           |            | Appl. Standa | rds/Procedu                                  | lures/Certificates |                 |                |                     |          | Supplier Name  |
|                                      |   |                            | 1           | Material      | Metrology                             |           | Welding    | <u>، ا</u>   | Cleaning                                     | <u>v</u>           | Weld Inspection |                | Leak dete           | ction    | /              |
| ·                                    |   |                            | M           | laterial cert | Dimensional note                      | e Welder  | Procedure  | NDT personel | Procedure                                    | Visual inspection  | X-ray procedure | e X-ray result | Procedure           | Operator | 1              |
| <u> </u>                             | 1   | ISO GPS                    |             | EN10028       | n/a                                   | IS09606-1 | ISO9606-2  | ISO9712      | EN12300                                      | ISO17637           | ISO17636        | ISO5817        | EN1779A1            | ISO9712  | /              |
| /                                    | 1   | →                          | 나는          | 2010020       |                                       |           | 1303000-2  | NDT Level 2  | ENIZOU                                       | 13017037           | 13017030        | Quality B      | EN1775A1<br>EN13185 | Level 2  |                |
| - 200                                | Manufacturing of cryogenic insertion  | LHCDFX 0112                | ┢╫┷╴        |               | r                                     | ISO14732  | —          | NDT Lever 2  | —  | <u>'</u> '         | <u>'</u> '      | Quanty 6       | ENISIOS             | Leverz   | <u>ار ا</u>    |
| 2.00                                 |   | LHCDFX_0112<br>LHCDFX_0026 | 4           | x             | h                                     | '         | <u> </u>   | t'           | <u> </u> '                                   | t                  |                 | +'             |                     | +        | Kompaflex+LTi  |
| 2.01                                 |   | LHCDFX 0025                |             | x             | rt                                    | '         | <u> </u>   | ·'           | '  | t                  | <u> </u>        | +'             |                     | +        | Kompaflex+LTi  |
| 2.02                                 |   | LHCDFX 0023                | <u>_</u>    | x             | rt                                    | '         | <u> </u>   | ·'           | '  | t                  |                 | +'             | <u> </u>            |          | Kompaflex+LTi  |
| 2.03                                 |   | LHCDFX 0029                |             | x             | ( <u> </u>                            |           |            | <u> </u>     |  |                    |                 | <u></u>        |                     | <u>+</u> | Kompaflex+LTi  |
| 2.04                                 |   | LHCDFX 0023                |             | x             |                                       | <u></u>   | <u> </u>   |              | <b>—</b> —                                   |                    |                 | <b>F</b>       |                     |          | LTi Metaltech  |
| 2.06                                 | Weld rigid elbows to flange   |                            |             | _ <u>_</u>    |                                       | x         | x          | x            | <u> </u>                                     |                    | <u> </u>        | <u> </u>       | <u> </u>            |          | LTi Metaltech  |
| 2.07                                 | Weld flexibles to rigid elbows  |                            |             |               |                                       | X         | X          | x            |  |                    |                 |                |                     |          | LTi Metaltech  |
| 2.08                                 | Weld adapting ends to flexibles   |                            |             |               | í l                                   | X         | X          | x            |  |                    |                 |                |                     |          | LTi Metaltech  |
| 2.09                                 |   |                            |             |               |                                       |           |            |              | x  |                    |                 |                |                     |          | LTi Metaltech  |
| 2.10                                 | X-ray of all joints in assembly   |                            | <u>i</u> tz |               |                                       |           |            |              | ,,   |                    | x               | x              |                     |          | LTi Metaltech  |
| 2.11                                 | Cleaning of all flexibles and end fittings  |                            |             |               |                                       |           |            |              | X  |                    |                 |                |                     |          | LTi Metaltech  |
| 2.12                                 | Independent leak detection of all flexible sub-assemblies   |                            |             |               |                                       |           |            |              |  |                    |                 |                | x                   | X        | LTi Metaltech  |
| 2.13                                 | Apply MLI to all flexibles  |                            |             |               |                                       |           |            |              |  |                    |                 |                |                     |          | SOTON          |
| 2.14                                 | Group and apply Nylon spacers to form bundle  |                            |             |               |                                       |           |            |              |  |                    |                 |                |                     |          | SOTON          |
| 2.15                                 |   | LHCDFX_0023                |             |               |                                       |           | '          | ′            | '  |                    |                 | ′              |                     |          | LTi Metaltech  |
| 2.16                                 | Weld outer cryogenic sleeve (90 Deg elbow) to mounting flange   | ST0307660                  |             |               |                                       | X         | X          | ·′           | '  | 1                  |                 | ′              |                     | _        | LTi Metaltech  |
| 2.17                                 | Weld outer cryogenic sleeve (90 Deg elbow + flange) to straight tube                                  | ST1197480                  | 4           |               |                                       | X         | X          | ·'           | '  | 1                  |                 | 4′             | 4                   |          | LTi Metaltech  |
| 2.18                                 | 2   | 4                          |             |               | X                                     | 4'        | <u> </u>   | ·'           | 4 <u> </u>                                   | 4                  | L               | 4′             | 4                   |          | LTi Metaltech  |
| 2.19                                 | Weld outer cryogenic sleeve (90 Deg elbow + flange + straight tube) to 45 Deg elbow                   | ST0307660 (Cut)            | 4           |               |                                       | X         | X          | 4'           | ·'   | 4                  | 4               | 4′             | 4                   |          | LTi Metaltech  |
| 2.20                                 | Weld outer cryogenic sleeve (90 Deg elbow + flange + straight tube + 45 Deg elbow) to straight tube 2 | ST1197515                  |             |               | <u></u>                               | X         | X          | 4'           | <u>                                     </u> | 4                  |                 | 4′             | 4                   | +        | LTi Metaltech  |
| 2.21                                 | Weld DN150 flange to asssembly to complete assembly   | ST1188239                  |             |               |                                       | X         | X          | ·'           | <b></b> '                                    | 4                  |                 | 4′             | 4                   | _        | LTi Metaltech  |
| 2.22                                 |   | ┡╴╴╴┚                      | 4           |               | ' X                                   | '         | <b></b> '  | 4'           | <u>                                     </u> | <b> </b>           | 4               | 4′             | 4                   |          | LTi Metaltech  |
| 2.23                                 | Clean all ports and surfaces  | 4                          | +           |               | · · · · · · · · · · · · · · · · · · · | '         | <b> </b> ' | <b></b> '    | x  | 1                  |                 | 4 <u> </u>     | 4                   |          | LTi Metaltech  |
| 2.24                                 | X-ray sample of butt welds and visually inspect welds to end flanges                                  | 4                          | 4           |               | <u> </u>                              | '         | <b> </b> ' | <b></b> '    | <b> </b> '                                   | x                  | x               | X              |                     |          | LTi Metaltech  |
| 2.25                                 | Perform leak detection of completed assembly  | 4                          | +           |               | ()                                    | '         | <b> </b> ' | <b></b> '    | <b> </b> '                                   | l                  |                 | 4′             | x                   | X        | LTI/SOTON/CERN |



#### HL-HLC: QUALITY - Manufacturing and Inspection Plan for DFX Cryostat

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|--|--|---------------|---------------|------------------|-----------|-----------|--------------|------------|-------------------|-----------------|--------------|-----------|----------|--|
|  | by: W. Bailey, Y.Yang  |               | _             |                  |           |           |              |            | _                 |                 |              |           |          |  |
|  | 02-2020  |               | Р             | roject: HL-      | LHC       |           |              |            | Su                | pplier: Un      | ni of Sou    | uthamap   | ton      |  |
| /erfied b  | у:   |               |               | -                |           |           |              |            |                   |                 |              | · · ·     |          |  |
| Date:  |  |               |               |                  |           |           |              |            |                   |                 |              |           |          |  |
| Approve  | he   |               | Wo            | rk Pacakge       | · W/P6a   |           |              |            |                   | Cli             | ent: CEI     | RN        |          |  |
|  | by.  |               | VV OI         | K I acakge       | . wroa    |           |              |            |                   | Cli             | ent. CLI     |           |          |  |
| Date:  |  |               |               |                  |           |           |              |            |                   |                 |              |           |          |  |
| No.  | Activity   | DWG ID Number |               |                  |           |           | Appl. Standa | rds/Proced | ures/Certificates |                 |              |           |          | Supplier Name  |
|  |  |               | Material      | Metrology        | 1         | Welding   |              | Cleaning   |                   | eld Inspection  |              | Leak dete | stion    |  |
|  |  |               |               |                  |           |           |              |            |                   |                 |              |           | -        |  |
|  |  |               | Material cert | Dimensional note | Welder    | Procedure | NDT personel | Procedure  | Visual inspection | X-ray procedure | X-ray result | Procedure | Operator |  |
|  |  | ISO GPS       | EN10028       | n/a              | IS09606-1 | ISO9606-2 | ISO9712      | EN12300    | ISO17637          | ISO17636        | ISO5817      | EN1779A1  | ISO9712  |  |
|  |  |               |               |                  | ISO14732  |           | NDT Level 2  |            |                   |                 | Quality B    | EN13185   | Level 2  |  |
|  |  |               |               |                  |           |           |              |            |                   |                 |              |           |          |  |
| 3.25   | Weld level straight guide tubes to flanges at either end to form sub-assembly  |               |               |                  | X         | X         |              |            |                   |                 |              |           |          | LTi Metaltech  |
| 3.26   |  |               |               | x                |           |           |              |            |                   |                 |              |           |          | LTi Metaltech  |
| 3.27   |  |               |               |                  |           |           |              | x          | ~                 | ~               | v            |           |          | LTi Metaltech  |
| 3.28   |  |               |               |                  |           |           |              |            | x                 | x               | x            | x         | ×        | LTi Metaltech<br>LTi Metaltech                                   |
|  | Perform leak detection   |               |               |                  | ~         | ~         |              |            |                   |                 |              |           | ×        |  |
| 3.30   | Weld extended level sensor guide tubes Clean surfaces after welding  |               |               |                  | x         | x         |              | x          |                   |                 |              |           |          | LTi Metaltech<br>LTi Metaltech                                   |
| 3.32   | Veld DN50 bellows to level sensor guide tube sub-assembly  |               | +             | <u> </u>         |           |           |              | <u> </u>   |                   |                 |              |           |          | LTi Metaltech  |
| 3.33   |  |               |               | ×                |           |           |              |            |                   |                 |              |           | + 1      | LTi Metaltech  |
| 3.34   |  |               |               | <b>^</b>         |           | x         |              |            |                   |                 |              |           |          | LTi Metaltech  |
| 3.35   |  |               |               |                  |           | <u>^</u>  |              |            | x                 | x               | x            |           |          | LTi Metaltech  |
| 3.36   | Weld completed level sensor guide tube sub-assembly to dome  |               | •             |                  |           |           |              |            | ^                 | ^               | <u>^</u>     |           |          | LTi Metaltech  |
| 3.37   | Check squareness between welded interface and top flange of level sensor guides  |               | 1             | x                |           |           |              |            |                   |                 |              |           |          | LTi Metaltech  |
| 3.38   |  |               | •             |                  |           |           |              | x          |                   |                 |              |           |          | LTi Metaltech  |
| 3.39   | X-ray weld   |               |               |                  |           |           |              | <u>^</u>   | x                 | x               | x            |           |          | LTi Metaltech  |
| 3.40   | Weld dome lifting pads to top dome in three locations  |               |               | - I              | x         | x         |              |            | ^                 | ~               | ^            |           |          | LTi Metaltech  |
| 3.41   | Check position of pads is within assigned tolerances   |               |               | x                | ~         | ~         |              | <u> </u>   |                   |                 |              |           |          | LTi Metaltech  |
| 3.42   | Clean all surfaces to finalise assembly  |               |               | <u> </u>         |           |           |              | x          |                   |                 |              |           | + 1      | LTi Metaltech  |
| 2141   |  |               | -             |                  |           |           |              |            | 1                 | i               | 1            | 1         |          |  |
| 4.00   | Manufacturing of other ancillaries for top dome + top flange assembly  |               |               |                  |           |           |              |            |                   |                 |              |           |          | 1  |
| 4.01   |  | LHCDFX 0015   | x             |                  |           |           |              |            |                   |                 |              |           |          | LTi Metaltech  |
| 4.02   | Vacuum braze/procure (with no flux) stainless steel to copper transition (x2) to form heating loop   |               |               |                  |           | X         |              |            |                   |                 |              |           |          | LTi Metaltech  |
| 4.03   | Clean tube assembly  |               | •             |                  |           |           |              | x          |                   |                 |              |           |          | LTi Metaltech  |
| 4.04   | Leak test tube assembly  |               |               |                  |           |           |              |            |                   |                 |              | x         | X        | LTi Metaltech  |
| 4.05   | Fabricate liquid in diffuser   | LHCDFX_0013   | x             |                  |           |           |              |            |                   |                 |              |           |          | LTi Metaltech  |
| 4.06   | Drill radial array of holes - Remove swarf and sharp edges   | 1             |               |                  |           |           |              |            |                   |                 |              |           |          | LTi Metaltech  |
| 4.07   | Weld diffuser end cap  |               |               |                  | X         | X         |              |            |                   |                 |              |           |          | LTi Metaltech  |
| 4.08   | Clean tube assembly  | 1             |               |                  |           |           |              | X          |                   |                 |              |           |          | LTi Metaltech  |
| 4.09   | Leak test tube assembly  |               |               | 1                |           |           |              |            |                   |                 |              | x         | Х        | LTi Metaltech  |
| 4.10   | Machine lifting/jacking tool components  | LHCDFX_0105   | x             |                  |           |           |              |            |                   |                 |              |           |          | LTi Metaltech  |
| 4.11   | Fabricate SV lower assembly  | LHCDFX_0131   | x             |                  |           |           |              |            |                   |                 |              |           |          | LTi Metaltech  |
| 4.11   |  | ST1207019     |               |                  | X         | X         | x            |            |                   |                 |              |           |          | LTi Metaltech  |
| 4.11   | Weld bellows to lip weld flange and straight tube to begin SV lower assembly   |               |               | X                |           |           |              |            |                   |                 |              |           |          | LTi Metaltech  |
| <b>4.12</b><br>4.13                                  | Weld bellows to lip weld flange and straight tube to begin SV lower assembly<br>Check length of tube + bellows is within nominal tolerance   |               |               | <u> </u>         |           |           |              |            |                   |                 |              |           |          |  |
| 4.12<br>4.13<br>4.14                                 | Check length of tube + bellows is within nominal tolerance<br>Weld concentric adapter to straight tube section   | LHCDFX_0090   |               |                  | x         | x         | x            |            |                   |                 |              |           |          | LTi Metaltech  |
| 4.12<br>4.13<br>4.14<br>4.15                         | Check length of tube + bellows is within nominal tolerance<br>Weld concentric adapter to straight tube section<br>Check distance between lip weld flange and lengthwise position of concentric adapter   | LHCDFX_0090   |               | x                |           |           | x            |            |                   |                 |              |           |          | LTi Metaltech  |
| 4.12<br>4.13<br>4.14<br>4.15<br>4.16                 | Check length of tube + bellows is within nominal tolerance<br>Weld concentric adapter to straight tube section<br>Check distance between lip weld flange and lengthwise position of concentric adapter<br>Weld rotatung DN63 flange assembly to top of straight tube   | LHCDFX_0090   |               | x                | x<br>x    | x         | X            |            |                   |                 |              |           |          | LTi Metaltech<br>LTi Metaltech                                   |
| 4.12<br>4.13<br>4.14<br>4.15<br>4.16<br>4.17         | Check length of tube + bellows is within nominal tolerance<br>Weld concentric adapter to straight tube section<br>Check distance between lip weld flange and lengthwise position of concentric adapter<br>Weld rotatung DNG3 flange assembly to top of straight tube<br>Check concentricty between SV value lower assembly   | LHCDFX_0090   |               |                  |           |           | x            |            |                   |                 |              |           |          | LTi Metaltech<br>LTi Metaltech<br>LTi Metaltech                  |
| 4.12<br>4.13<br>4.14<br>4.15<br>4.16<br>4.17<br>4.18 | Check length of tube + bellows is within nominal tolerance<br>Weld concentric adapter to straight tube section<br>Check distance between lip weld flange and lengthwise position of concentric adapter<br>Weld rotatung DN63 flange assembly to top of straight tube<br>Check concentricty between SV value lower assembly<br>X-ray a selection of welds within the completed assembly | LHCDFX_0090   |               | x                |           |           | X            |            | x                 | x               | x            |           |          | LTi Metaltech<br>LTi Metaltech<br>LTi Metaltech<br>LTi Metaltech |
| 4.12<br>4.13<br>4.14<br>4.15<br>4.16<br>4.17         | Check length of tube + bellows is within nominal tolerance<br>Weld concentric adapter to straight tube section<br>Check distance between lip weld flange and lengthwise position of concentric adapter<br>Weld rotatung DNG3 flange assembly to top of straight tube<br>Check concentricty between SV value lower assembly   | LHCDFX_0090   |               | x                |           |           | ×            | x          | x                 | x               | x            | x         |          | LTi Metaltech<br>LTi Metaltech<br>LTi Metaltech                  |



#### HL-HLC: QUALITY - Manufacturing and Inspection Plan for DFX Cryostat

| Prepared<br>Date: 20-0 | by: W. Bailey, Y.Yang<br>12-2020   |               | p             | roject: HL-L            | нс         |            |              |             | Su                | pplier: Un      | i of Sou     | thamant   | on                  |                        |
|------------------------|--|---------------|---------------|-------------------------|------------|------------|--------------|-------------|-------------------|-----------------|--------------|-----------|---------------------|------------------------|
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| Date:                  |  |               |               |                         |            |            |              |             |                   |                 |              |           |                     |                        |
|                        |  | 1             | 14/~          |                         |            |            |              |             |                   | cl:             | ent: CEF     | DNI .     |                     |                        |
| Approved               | by:  |               | VVOI          | 'k Pacakge:             | wPba       |            |              |             |                   | Clie            | ent: CEF     | (IN       |                     |                        |
| Date:                  |  |               | _             |                         |            |            |              |             |                   |                 |              |           |                     |                        |
| No.                    | Activity   | DWG ID Number |               |                         |            |            | Appl. Standa | rds/Procedu | ures/Certificates |                 |              |           | S                   | Supplier Name          |
|                        |  |               | Material      | Metrology               |            | Welding    |              | Cleaning    | W                 | eld Inspection  |              | Leak dete | tion                |                        |
|                        |  |               | Material cert | <b>Dimensional note</b> | Welder     | Procedure  | NDT personel | Procedure   | Visual inspection | X-ray procedure | X-ray result | Procedure | Operator            |                        |
|                        |  | ISO GPS       | 51140000      | - (-                    | 10000000 4 | 10000000.0 | 1000740      | 51112200    | 10017627          | 10017525        | 1005017      | EN122044  | 1000740             |                        |
|                        |  | 100 01 0      | EN10028       | n/a                     | ISO9606-1  | ISO9606-2  | ISO9712      | EN12300     | ISO17637          | ISO17636        | IS05817      | EN1779A1  | ISO9712             |                        |
|                        |  |               |               |                         | ISO14732   |            | NDT Level 2  |             |                   |                 | Quality B    | EN13185   | Level 2             |                        |
| <u>11.00</u>           | Manufacturing of top dome + top flange assembly  | LHCDFX_0145   |               |                         |            |            |              |             |                   |                 |              |           | $ \longrightarrow $ |                        |
| 11.01                  | Install SV vacuum tube assembly to top dome  |               |               |                         |            |            |              |             |                   |                 |              |           |                     | LTi Metaltech          |
| 11.02                  | Install cryogenic insertion assembly to top dome and engage flanges for welding                                  | LHCDFX_0112   | ╟──┏          |                         |            |            |              |             |                   | +               |              |           |                     | L <u>Ti Me</u> taltech |
| 11.03                  | Support top flange above top dome  |               |               |                         |            |            |              |             |                   |                 |              |           |                     | LTi Metaltech          |
| 11.04                  | Clean all O-ring selaing interfaces  |               |               |                         |            |            |              | X           |                   |                 |              |           |                     | LTi Metaltech          |
| 11.05                  | Ensure Seal + SV vacuum tube assmebly installed to top flange  |               |               |                         |            |            |              |             |                   |                 |              |           |                     | LTi Metaltech          |
| 11.06                  | Align and thread cryogenic insertion bundle through correct bore in top flange without snagging MLI              |               |               |                         |            |            |              |             |                   |                 |              |           |                     | LTi Metaltech          |
| 11.07                  | Ensure level gauge guide tube assembly fixed to top dome is aligned with correct bore in top flange              |               |               | X                       |            |            |              |             |                   |                 |              |           |                     | LTi Metaltech          |
| 11.08                  | Install lifting tool stud bars to join top dome with top flange  |               |               |                         |            |            |              |             |                   |                 |              |           | -                   | LTi Metaltech          |
| 11.09                  | Install SV lower assembly + MLI through the top flange until weld flange engages port in top dome                | LHCDFX_0091   | 4             |                         |            |            |              |             |                   |                 |              |           |                     | LTi Metaltech          |
| 11.10                  | Use jacking mechanism to separate a fixed distance between top flange and top dome                               |               |               |                         |            |            |              |             |                   |                 |              |           |                     | LTi Metaltech          |
| 11.11                  | Ensure parallism between the bottom of top dome and base of top dome   |               |               | X                       |            |            |              |             |                   |                 |              |           |                     | LTi Metaltech          |
| 11.12                  | Install Seal and cryogenic insertion assembly outer vacuum sleeve assembly                                       |               |               |                         |            |            |              |             |                   |                 |              |           |                     | LTi Metaltech          |
| 11.13                  | Slide cryogenic insertion bundle through elbow section and fix mating flange to top flange                       |               |               |                         |            |            |              |             |                   |                 |              |           | + +                 | LTi Metaltech          |
| 11.14                  | Ensure welded interfaces are cleaned   |               |               |                         |            |            |              | X           |                   |                 |              |           |                     | LTi Metaltech          |
| 11.15                  | Weld both cryogenic insertion flanges to top dome  |               |               |                         | X          | X          | x            |             |                   |                 |              |           |                     | LTi Metaltech          |
| 11.16                  | Weld engaged flange of SV lower assembly to top dome   |               |               |                         | X          | X          |              |             |                   |                 |              |           |                     | LTi Metaltech          |
| 11.17                  | Weld engaged flange of level sensor guide tube assembly to top dome  |               |               |                         | X          | X          |              |             |                   |                 |              |           |                     | LTi Metaltech          |
| 11.18                  | Clean surfaces after welding   |               |               |                         |            |            |              | X           |                   |                 |              |           |                     | LTi Metaltech          |
| 11.19                  | X-ray 3 welds  |               |               |                         |            |            |              |             | x                 | X               | X            |           |                     | LTi Metaltech          |
| 11.20                  | Weld upper flange of SV lower assembly engaging with SV outer vacuum tube mounted to top flange                  |               |               |                         | X          | X          |              |             |                   |                 |              |           |                     | LTi Metaltech          |
| 11.21                  | Clean surfaces after welding   |               |               |                         |            |            |              | X           |                   |                 |              |           |                     | LTi Metaltech          |
| 11.22                  | Inspect welds  |               |               |                         |            |            |              |             |                   |                 |              |           |                     | LTi Metaltech          |
| 11.23                  | If another weld is introduced to shorten length of the level sensor guide tubes - Could perform a leak detection |               |               |                         |            |            |              |             | x                 |                 |              |           |                     | LTi Metaltech          |
| 11.24                  | Install blanking flange to top of SV assembly  |               |               |                         |            |            |              |             |                   |                 |              |           |                     | LTi Metaltech          |
| 11.25                  | Install Seal + level sensor guide vacuum lower assembly to top flange  | LHCDFX_0118   |               |                         |            |            |              |             |                   |                 |              |           |                     | LTi Metaltech          |
| 11.26                  | Install Seal + level sensor guide vacuum upper vessel to vacuum pipe assembly                                    | LHCDFX_0120   |               |                         |            |            |              |             |                   |                 |              |           |                     | LTi Metaltech          |
| 11.27                  | Install blanking flange to top of level sensor guide tube assembly   | + <u> </u>    |               |                         |            |            |              |             |                   |                 |              |           |                     | LTi Metaltech          |
| 11.28                  | Install blanks to cryogenic insertion lines  |               |               |                         |            |            |              |             |                   |                 |              |           |                     | LTi Metaltech          |
| 11.29                  | Perform leak detection test of top dome assembly with welded ports   |               |               |                         |            |            |              |             |                   |                 |              | x         |                     | LTi Metaltech          |
| 11.30                  | Apply MLI blankets to top dome and complete wraps to vertical tube walls   |               |               |                         |            |            |              |             |                   |                 |              |           | 5                   | SOTON                  |



DFX (proto) PRR – 03 MAR 2020

### **Procedures - fabrication and inspection (F&I)**



### **Key standards for F&I**

#### DFX design rules EN 13445 EN 14917+A1 PED 2014/68/EU Engineering drawings ISO GPS EN 10028-7 (plate) EN 10088-3 (std. delivery conditions) Procurement of materials EN 10216-5 (seamless tubes) EN 10217-7 (welded tubes) and certification\* ISO 10380:2012 (flexibles) EN 12300 Cleaning ISO 5817 (fusion welding => Quality B) ISO 9601-1 (welder qualification) Welding EN ISO 15609-1 (welding procedures) EN ISO 15614-1 (welding procedure tests) EN ISO 9712 (NDT personnel => Level 2) ISO 17637 (welds – visual inspection) Weld inspection ISO 17636 (welds - radiography) ISO 5817 (weld inspection result) EN 13187 (leak detection method) Leak detection ISO 9712 (leak detection operator => Level 2) EN 13485 (vessel testing methods) Pressure testing LHC PROJEC PED 2014/68/EU (pressure test)

DFX - 03 MAR 2020

## F&I (HOLD Points)

A HOLD point: = CERN/authorised representative, is informed that a specific step has been completed.

The work-flow is stopped until CERN, or its authorized representative, provides a Hold Point Clearance.

- The clearance is provided within 5 working days upon submission of the quality control documentation relative to the performed step.
- In case of clearance the work-flow can continue.
- In case of rejection, a recovery plan shall be discussed with CERN and submitted to CERN for final approval within 10 working days.

Typically a HOLD point has been introduced to bring closure to an activity, i.e. the final leak detection/ pressure test performed to confirm completion of a sub-assembly after completion of a critical weld/dimension check

A total of 15 HOLD points (H) have been introduced into the DFX F&I schedule



#### DFX PRR (Proto) – 03 MAR 2020

### F&I (HOLD Points)

| HL                  | HLC: QUALITY - Manufacturing and Inspection Plan for  | DF)      | (Cryostat          | : (SH  | IORT O         | /ER      | VIEW)               |               | 1             | 1              |                | C                    | DFX F                | roto            | ) - Pr          | odu               | ctior             | n Pla        | n            |               |               |               |             |
|---------------------|---|----------|--------------------|--------|----------------|----------|---------------------|---------------|---------------|----------------|----------------|----------------------|----------------------|-----------------|-----------------|-------------------|-------------------|--------------|--------------|---------------|---------------|---------------|-------------|
|                     | oy: W. Bailey, Y.Yang   |          | Eq. Code:          |        |                |          | Asset Code: (L      | 1-2)          | 3-4)          | 1-2)           | 3-4)           |                      |                      | 1-2)            | 3-4)            | 1-2)              | 3-4)              | 1-2)         | 3-4)         | 1-2)          | 3-4)          | 1-2)          | 3-4)        |
| Verfied by<br>Date: |   | Item     | description: DFX   | ( Cryo | stat (Proto)   |          | EDMS Report         | 2020 (WEEK 1- | 2020 (WEEK 3- | /EEK 1         | /EEK 3-        | VEEK 1               | VEEK 3               | /EEK 1-         | /EEK 3-         |                   |                   | 2020 (WEEK 1 | 2020 (WEEK 3 | 2020 (WEEK 1- | 2020 (WEEK 3- | 2020 (WEEK 1- | (WEEK 3-    |
| Approved<br>Date:   | by:   | <u> </u> |                    | In     | spection       |          |                     | 2             | 2             | 2              | 5              | 2                    | 2                    | 2               | Š               | 50 (              | 20 (              | 2            | 2            | 3             | 2             | 5             | 2           |
|                     | Activity  | Man      | ufacturer/ Control |        |                | ent/3r   | rd Party / Surveila | Apr 2020      | Apr 2020      | May 2020 (WEEK | May 2020 (WEEK | June 2020 (WEEK 1-2) | June 2020 (WEEK 3-4) | July 2020 (WEEK | July 2020 (WEEK | August 2020 (WEEK | August 2020 (WEEK | Sept 202     | Sept 202     | Oct 2020      | Oct 2020      | Nov 202(      | Nov 2020    |
|                     |   | Code     | Signature/Date     | Code   | Signature/Date | Code     | Signature/Date      | 1             |               | 2              | 2              | -                    | -                    |                 | -               | Au                | Au                | s            | s            | Ŭ             | Ŭ             | ~             | ~           |
|                     | Procurement of materials/off-shelf components/bellows/flexibles   |          |                    |        |                |          |                     |               |               |                |                |                      |                      |                 |                 |                   |                   |              |              |               |               |               |             |
| 0.08                | Completion of procurement of bellows (x7)   | Н        | x                  | н      | x              | н        | x                   |               |               |                |                |                      |                      |                 |                 |                   |                   |              |              |               |               | ]             | ⊢]/         |
| <u>3.00</u>         | Manufacturing of top dome assembly  |          |                    |        |                |          |                     |               |               |                |                |                      |                      |                 |                 |                   |                   |              |              |               |               | ]             | ⊢]/         |
| 3.42                | Clean all surfaces to finalise assembly   | н        | x                  | н      | x              | н        | x                   |               |               |                |                |                      |                      |                 |                 |                   |                   |              |              |               |               |               | ⊢ /         |
| 7.00                | Manufacturing of mid-section sub-assembly   |          |                    |        |                |          |                     |               |               |                |                |                      |                      |                 |                 |                   |                   |              |              |               |               |               | ⊢  <b>/</b> |
| 7.10                | Check dimensions, tolerances and surface finish of completed components X-ray weld - VB membrane to ISO680 flange   | H        | x                  | H<br>H | x<br>x         | H<br>H   | x                   |               |               |                |                |                      |                      |                 |                 |                   |                   |              |              |               |               |               | ⊢  <i>¶</i> |
|                     | A-ray weid - vB memorane to isobau nange<br>Manufacturing of additional vertical vacuum vessel components           | н        |                    | н      |                | н        | ^                   |               |               |                |                |                      |                      |                 |                 |                   |                   |              |              |               |               |               | r           |
| 8.25                | Leak detect VV sliding sleeve using blanking flanges to close ports and large blanking plated to close ring flanges | н        | x                  | н      | x              | н        | x                   |               |               |                |                |                      |                      |                 |                 |                   |                   |              |              |               |               |               |             |
| 9.00                | Manufacturing of "cold" elbow   | п        | ^                  | n      | ^              | <b>n</b> | <u>^</u>            |               |               |                |                |                      |                      |                 |                 |                   |                   |              |              |               |               |               |             |
| 9.38                | Check leak tightness + pressure test of elbow using special clamps for lip weld flanges                             | н        | x                  | н      | x              | н        | x                   |               |               |                |                |                      |                      |                 |                 |                   |                   |              |              |               |               | $\rightarrow$ |             |
|                     | Manufacturing of top dome + top flange assembly   |          | ~                  |        | ~              |          | ~                   |               |               |                |                |                      |                      |                 |                 |                   |                   |              |              |               |               | $\rightarrow$ |             |
| 11.29               | Perform leak detection test of top dome assembly with welded ports  | н        | x                  | н      | x              | н        | x                   |               |               |                |                |                      |                      |                 |                 |                   |                   |              |              |               | $\rightarrow$ | $\rightarrow$ |             |
| 12.00               | Manufacturing of top dome + top flange assembly with mid-section assembly   |          |                    |        |                |          |                     |               |               |                |                |                      |                      |                 |                 |                   |                   |              |              |               |               |               |             |
| 12.14               | X-ray weld of top dome + bottom dome  | н        | x                  | н      | x              | н        | x                   |               |               |                |                |                      |                      |                 |                 |                   |                   |              |              |               |               |               |             |
| 15.00               | Manufacture of cold horizontal section 1  |          |                    |        |                |          |                     |               |               |                |                |                      |                      |                 |                 |                   |                   |              |              |               |               | $\rightarrow$ |             |
| 15.52               | Perform pressure test of sub-assembly   | н        | x                  | н      | x              | н        | x                   |               |               |                |                |                      |                      |                 |                 |                   |                   |              |              |               |               |               |             |
| <u>16.00</u>        | Manufacture of VV horizontal section 1  |          |                    |        |                |          |                     |               |               |                |                |                      |                      |                 |                 |                   |                   |              |              |               |               |               |             |
| 16.40               | Perform leak detection of closed assembly - using special blanks plates to perform test                             | Н        | x                  | н      | x              | н        | x                   |               |               |                |                |                      |                      |                 |                 |                   |                   |              |              |               |               |               |             |
| <u>18.00</u>        | Manufacture of "cold" horizontal sliding sleeve TEST  |          |                    |        |                |          |                     |               |               |                |                |                      |                      |                 |                 |                   |                   |              |              |               |               | 7             |             |
| 18.14               | Perform pressure test of sub-component by installing seals, split clamping rings and blanks flanges                 | н        | x                  | н      | x              | н        | x                   |               |               |                |                |                      |                      |                 |                 |                   |                   |              |              |               |               | ]             | ⊢           |
|                     | Manufacture of "cold" horizontal sliding sleeve REAL PART   |          |                    |        |                |          |                     |               |               |                |                |                      |                      |                 |                 |                   |                   |              |              |               |               | ]             | ⊢−−−↓       |
|                     | Manufacture of cold horizontal IFS section  |          |                    |        |                |          |                     |               |               |                |                |                      |                      |                 |                 |                   |                   |              |              |               |               | ]             |             |
| 21.37               | X-ray welds x6 IFS small lip weld flanges   | н        | x                  | н      | x              | н        | x                   |               |               |                |                |                      |                      |                 |                 |                   |                   |              |              |               |               |               | ┌───┤       |
| 22.00               | Manufacture of VV horizontal IFS section  |          | v                  |        | *              |          | ×                   |               |               |                |                |                      |                      |                 |                 |                   |                   |              |              |               |               |               | ⊢ <b> </b>  |
| 22.36               | Perform leak detection  | н        | x                  | н      | x              | н        | x                   | -             |               |                |                |                      |                      |                 |                 |                   |                   |              |              |               |               |               |             |
| 29.00<br>29.11      | Manufacturing of cold IFS section with VV IFS section Inspect welds of IFS vacuum manifolds                         | н        | x                  | н      | x              | н        | ×                   |               |               |                |                |                      |                      |                 |                 |                   |                   |              |              |               |               |               | r  _        |
| 32.00               | Inspect weids of IPS vacuum manifolds Manufacturing of DFX for pressure test  | п        | ^                  | •      | ^              | n        | ^                   |               | -             | -              |                |                      |                      |                 |                 |                   |                   |              |              |               |               |               |             |
| 32.10               |   | н        | x                  | н      | x              | н        | x                   |               |               |                |                |                      |                      |                 |                 |                   |                   |              |              |               |               |               |             |
|                     | DFX pressure testing  |          | ~                  |        | ~              |          | ~                   |               |               |                |                |                      |                      |                 |                 |                   |                   |              |              |               |               |               |             |
|                     |   |          |                    |        |                |          |                     |               |               |                |                |                      |                      |                 |                 |                   |                   |              |              |               |               |               |             |
|                     |   |          |                    |        |                |          | -                   |               |               |                |                |                      |                      |                 |                 |                   |                   |              |              |               |               |               |             |



### F&I (NOTIFIED Points)

A NOTIFIED point: = CERN/authorised representative, is informed 5 working days in advance that a specific step has been completed and that the following step in the approved work-flow will be performed.

Notification Point does not affect the work-flow. Work can continue without CERN/authorised representatives reply

A total of 24 NOTIFIED points (N) have been introduced into the DFX F&I schedule



#### DFX PRR (Proto) – 03 MAR 2020



|         |   |      |   |   |   |          |   | <br>1 | <br> | <br> | i |  | 1 | <br> | <br> |
|---------|---|------|---|---|---|----------|---|-------|------|------|---|--|---|------|------|
| 0.00 P  | ocurement of materials/off-shelf components/bellows/flexibles   |      |   |   |   |          |   |       |      |      |   |  |   |      |      |
| 0.09    | Completion of procurment of flexibles   | N    | X | N | х | N        | х |       |      |      |   |  |   |      |      |
|         | anufacturing of top flange  |      |   |   |   |          |   |       |      |      |   |  |   |      |      |
| 1.36    | Perform leak detection of level gauge VV lower + upper assembly to complete all small sub-assemblies                                    | N    | x | N | x | N        | x |       |      |      |   |  |   |      |      |
| 2.00 N  | anufacturing of cryogenic insertion   |      |   |   |   |          |   |       |      |      |   |  |   |      |      |
| 2.25    | Perform leak detection of completed assembly  | N    | x | N | x | N        | x |       |      |      |   |  |   |      |      |
|         | anufacturing of other ancillaries for top dome + top flange assembly  |      |   |   |   |          |   |       |      |      |   |  |   |      |      |
|         | X-ray a selection of welds within the completed assembly  | N    | X | N | x | N        | x |       |      |      |   |  |   |      |      |
|         | anufacturing of outer fountain assembly   |      |   |   |   |          |   |       |      |      |   |  |   |      |      |
|         | X-ray weld of outer fountain flange to fountain base flange   | N    | x | N | x | N        | x |       |      |      |   |  |   |      | <br> |
|         | anufacturing of mid-section sub-assembly  |      |   |   |   |          |   |       |      | <br> |   |  |   |      | <br> |
|         | Route electrical wiring through opposing tubes on inner fountain wall to complete assembly  | N    | x | N | x | N        | x |       |      |      |   |  |   |      | <br> |
|         | anufacturing of "cold" elbow  |      |   |   |   | +        |   |       |      |      |   |  |   |      | <br> |
|         | Perform electrical test and record data   | N    | x | N | x | N        | x |       |      |      |   |  |   |      | <br> |
|         | anufacturing of lower VV cross section  |      |   |   |   |          |   |       |      |      |   |  |   |      | <br> |
| 10.21   | Perform leak detection of assembly  | N    | x | N | x | N        | x |       |      | <br> |   |  |   |      | <br> |
|         | anufacturing of top dome + top flange assembly  |      |   |   |   |          |   |       |      |      |   |  |   |      | <br> |
|         | X-ray 3 welds of ports closures in top dome   | N    | X | N | X | N        | x |       |      | <br> |   |  |   |      | <br> |
|         | Adjust lifting jacks to nominal height between bottom of top flange and base of top dome to complete assemb;y                           | N    | x | N | X | N        | x |       |      |      |   |  |   |      | <br> |
|         | anufacturing of top dome + top flange assembly with mid-section assembly  |      |   |   |   | +        |   |       |      |      |   |  |   |      | <br> |
| 12.16   | Re-position top dome MLI blanket and install MLI blanket to bottom dome   | N    | x | N | X | N        | X |       |      | <br> |   |  |   |      | <br> |
|         | anfacturing of "cold" elbow + VV cross section<br>anfacturing of combined top + mid-section assembly to lower elbow + VV cross assembly |      |   |   |   |          |   |       |      |      |   |  |   |      | <br> |
|         |   | N    | x | N | x | N        | x |       |      | <br> |   |  |   |      | <br> |
|         | Elevate VV cross section and close vacuum by fitting clamps<br>anufacture of cold horizontal section 1                                  | N    | × | N | × | N        | X |       |      |      |   |  |   |      | <br> |
|         | X-ray weld of long tube section Dia219 to end of bellows  | N    | x | N | x | N        | x |       |      |      |   |  |   |      | <br> |
|         | anufacture of VV horizontal section 1   | - 14 | ^ | N | ^ |          | ^ |       |      |      |   |  | - |      |      |
|         | Inspect weld of ISO630 reducer flange to bellows  | N    | x | N | x | N        | x |       |      |      |   |  | - |      |      |
|         | anufacture of "cold" horizontal sliding sleeve TEST   |      | ^ |   | ~ | <u> </u> | ~ |       |      |      |   |  |   |      |      |
|         | Perform pressure test of sub-component by installing seals, split clamping rings and blanks flanges                                     | N    | x | N | x | N        | x |       |      |      |   |  |   |      |      |
|         | anufacture of "cold" horizontal sliding sleeve REAL PART  |      |   |   |   | <u> </u> |   |       |      |      |   |  |   |      |      |
|         | Perform pressure test of sub-component with a piston seal at the flared end and gasket seal at weld ring end                            | N    | x | N | x | N        | x |       |      |      |   |  |   |      |      |
|         | anufacture of VV horizontal sliding sleeve  |      |   |   |   |          |   |       |      |      |   |  |   |      |      |
|         | Perform leak detection test   | N    | x | N | x | N        | x |       |      |      |   |  |   |      |      |
| 21.00 N | anufacture of cold horizontal IFS section   |      |   |   |   |          |   |       |      |      |   |  |   |      |      |
| 21.35   | Weld x6 IFS small lip weld flange   | N    | x | N | x | N        | x |       |      |      |   |  |   |      |      |
| 23.00 N | anufacture of VV horizontal sleeve - plug end   |      |   |   |   |          |   |       |      |      |   |  |   |      |      |
| 23.11   | Perform leak detection test   | N    | x | N | х | N        | х |       |      |      |   |  |   |      |      |
| 25.00 N | anufacturing of cold horizontal section 1 to DFX vertical section   |      |   |   |   |          |   |       |      |      |   |  |   |      |      |
| 25.06   | Support cold horizontal section 1 whilst installing split ring clamps and bolting   | N    | x | N | x | N        | x |       |      |      |   |  |   |      |      |
| 27.00 N | anufacturing of cold sliding sleeve (TEST) with DFX   |      |   |   |   |          |   |       |      |      |   |  |   |      |      |
|         | Align correct corresponding flanges and install bolting   | N    | x | N | x | N        | x |       |      |      |   |  |   |      |      |
|         | anufacturing of VV plug end section to DFX  |      |   |   |   |          |   |       |      |      |   |  |   |      |      |
|         | Install IFS (plug end) blanking plate with gasket seal and bolting  | N    | x | N | х | Ν        | х |       |      |      |   |  |   |      |      |
|         | X pressure testing  |      |   |   |   |          |   |       |      |      |   |  |   |      |      |
|         | Perform pressure test at room temperature and 4.9 bar applied to DFX helium vessel  | N    | x | Ν | x | Ν        | x |       |      |      |   |  |   |      |      |
| 33.03   | Review pressure test data   | N    | x | N | x | N        | x |       |      |      |   |  |   |      |      |
|         |   |      |   |   |   |          |   |       |      |      |   |  |   |      |      |



### F&I (WITNESS Points)

A WITNESS point: = CERN/authorised representative, intends to attend any specific step of the production. The supplier will notify the client with 10 working days in advance that the activity will be performed.

At this stage in the project plan SOTON will need some guidance as to the typical number of witness points CERN/authorised representatives anticipate to factor in the production plan

A total of 31 WITNESS points (W) have been introduced into the DFX F&I schedule for SOTON and LTi Metaltech to be jointly present – these can be adapted to include a CERN/representative.

Alternatively, previous HOLD or NOTIFIED points changed to WITNESS points so an observation is carried out onsite



### **F&I (Potential Witness Points)**

| HL-HLC: QUALITY - Manufacturing and Inspecti   | on Plan | for DF         | X Cr      | yostat (         | SHO      | RT OVE              | RVIEV     | V)         |    | E    | xan      | npl            | e c   | of a      | ddi   | ng        | to a  | an    | exis     | stin      | g        |          |       |       |       |              |
|--|---------|----------------|-----------|------------------|----------|---------------------|-----------|------------|----|------|----------|----------------|-------|-----------|-------|-----------|-------|-------|----------|-----------|----------|----------|-------|-------|-------|--------------|
| by: W. Bailey, Y.Yang<br>12-2020   | Item E  | q. Code:       |           |                  |          | Asset Code: (       | LHC Part  | dentifier) |    | 2    | ecia     | nn             | nor   | ht.       |       | -         |       |       |          |           | -        |          |       |       | 1     | <del>(</del> |
| :  |         |                |           |                  |          |                     |           |            |    | a    | ssig     | JIIII          | ICI   | π.        |       |           |       |       |          |           |          |          |       |       |       | 3-4)         |
|  | Item de | escription: D  | FX Cryo   | ostat (Proto     | )        | EDMS Report         | t No: 233 | 7452       |    |      | rov      | 1              | f lir | <b>``</b> | പപ    | of        | hat   | ton   | n fl     | <u></u>   | in i     |          | ha    |       | ÷.    | Ť            |
| by:  |         |                | -         |                  |          |                     |           |            |    |      | -ray     | y Ui           | որ    | JVV       | eiu   | <b>UI</b> | DOI   | lon   | [] []ē   | ang       | je i     |          | DU    | /V    |       | Ň            |
|  |         |                |           | Inspection       | n        |                     |           |            |    |      | <u> </u> | <b>.</b>       | ~ 1   | ~         |       | ē.        | 5     | 0     | Ä        |           | ~        | ~        |       |       | 5     | 0            |
|  | Manufa  | acturer/Contro | ol Instit | ute / Verificati | onent/3r | rd Party / Surveila | Rev. Doc. | Notes      |    |      |          | 202            | y 202 | y 202     | e 202 | e 202     | , 202 | , 202 | ugust 20 | August 20 | Sept 202 | Sept 202 | : 202 | : 202 | , 202 | , 2020 (WEEK |
| Activity   |         |                |           |                  |          |                     |           |            |    |      | Apr      | Apr            | May   | May       | June  | June      | ylul  | γInL  | n Br     | ng l      | e        | e        | Oct   | Oct   | Νον   | Nov          |
|  | Code    | Signature/Date | e Code    | Signature/Da     | te Code  | Signature/Date      |           |            |    |      |          |                | ~     | ~         |       | -         | -     | -     | βΓ       | ¥         | ~        | Š        | •     | -     | ~     |              |
| Manufacturing of top flange  |         |                |           |                  |          |                     |           |            |    |      |          |                |       |           |       |           |       |       |          |           |          |          |       |       |       |              |
| Vacuum braze/procure (with no flux) stainless steel to copper transition (x2) to form heating loop | w       | x              | w         | x                |          |                     |           |            |    |      |          |                |       |           |       |           |       |       |          |           |          |          |       |       |       |              |
| X-ray weld of outer fountain flange to fountain base flange  | N       | x              | N         | x                | N        | x                   |           |            |    |      |          |                |       |           |       |           |       |       |          |           |          |          |       |       |       |              |
| Manufacturing of mid-section sub-assembly  |         |                |           |                  |          |                     |           |            |    |      |          |                |       |           |       |           |       |       |          |           |          |          |       |       |       |              |
| X-ray weld - VB membrane to ISO680 flange  | н       | x              | н         | x                | н        | X                   |           |            |    |      |          |                |       |           |       |           |       |       |          |           |          |          |       |       |       |              |
| Manufacturing of additional vertical vacuum vessel components                                      |         |                |           |                  |          |                     |           |            |    |      |          |                |       |           |       |           |       |       |          |           |          |          |       |       |       |              |
| Manufacturing of "cold" elbow  |         |                |           |                  |          |                     |           |            |    |      |          |                |       |           |       |           |       |       |          |           |          |          |       |       |       |              |
| X-ray lip weld of bottom flange to elbow assembly  | w       | х              | w         | x                | -        |                     |           |            |    |      |          |                |       |           |       |           |       |       |          |           |          |          |       |       |       |              |
| Manufacturing of top dome + top flange assembly  |         |                |           |                  |          |                     |           |            |    |      |          |                |       |           |       |           |       |       |          |           |          |          |       |       |       |              |
| Perform leak detection test of top dome assembly with welded ports                                 | н       | x              | н         | x                | н        | X                   |           |            |    |      |          |                |       |           |       |           |       |       |          |           |          |          |       |       |       |              |
| Manufacturing of top dome + top flange assembly with mid-section assembly                          |         |                |           |                  |          |                     |           |            |    |      |          |                |       |           |       |           |       |       |          |           |          |          |       |       |       |              |
| X-ray weld of top dome + bottom dome   | н       | х              | н         | x                | н        | X                   |           |            |    |      |          |                |       |           |       |           |       |       |          |           |          |          |       |       |       |              |
| Manfacturing of combined top + mid-section assembly to lower elbow + VV cross assembly             |         |                |           |                  |          |                     |           |            |    |      |          |                |       |           |       |           |       |       |          |           |          |          |       |       |       |              |
| Elevate VV cross section and close vacuum by fitting clamps  | N       | х              | N         | x                | N        | X                   |           |            |    |      |          |                |       |           |       |           |       |       |          |           |          |          |       |       |       |              |
| Manufacture of cold horizontal section 1   |         |                |           |                  |          |                     |           |            |    |      |          |                |       |           |       |           |       |       |          |           |          |          |       |       |       |              |
| X-ray weld of long tube section Dia219 to end of bellows   | N       | x              | N         | x                | N        | x                   |           |            |    |      |          |                |       |           |       |           |       |       |          |           |          |          |       |       |       |              |
| Perform leak detection test  | w       | х              | w         | x                |          |                     |           |            |    |      |          |                |       |           |       |           |       |       |          |           |          |          |       |       |       |              |
| Perform pressure test of sub-assembly  | н       | х              | н         | x                | н        | x                   |           |            |    |      |          |                |       |           |       |           |       |       |          |           |          |          |       |       |       |              |
| Apply MLI blankets to all external interfaces  |         |                |           |                  |          |                     |           | N          |    |      |          |                |       |           |       |           |       |       |          |           |          |          |       |       |       |              |
| Manufacture of VV horizontal section 1   |         |                |           |                  |          |                     |           |            |    |      |          |                |       |           |       |           |       |       |          |           |          |          |       |       |       |              |
| Inspect weld of ISO630 reducer flange to bellows   | N       | x              | N         | x                | N        | x                   |           |            |    |      |          |                |       |           |       |           |       |       |          |           |          |          |       |       |       |              |
| Perform leak detection of closed assembly - using special blanks plates to perform test            | н       | x              | н         | x                | н        | X                   |           |            |    |      |          |                |       |           |       |           |       |       |          |           |          |          |       |       |       |              |
| Manufacture of "cold" horizontal sliding sleeve REAL PART  |         |                |           |                  |          |                     |           |            |    |      |          |                |       |           |       |           |       |       |          |           |          |          |       |       |       |              |
| X-ray weld of flared ring to tube  | w       | x              | w         | x                |          |                     |           |            |    |      |          |                |       |           |       |           |       |       |          |           |          |          |       |       |       |              |
| Manufacture of cold horizontal IFS section   |         |                |           |                  |          |                     |           |            |    |      |          |                |       |           |       |           |       |       |          |           |          |          |       |       |       |              |
| Weld x6 IFS small lip weld flange  | N       | x              | N         | x                | N        | X                   |           |            |    |      |          |                |       |           |       |           |       |       |          |           |          |          |       |       |       |              |
| X-ray welds x6 IFS small lip weld flanges  | н       | x              | н         | x                | н        | x                   |           |            |    |      |          |                |       |           |       |           |       |       |          |           |          |          |       |       |       |              |
| Manufacturing of cold IFS section with VV IFS section  |         |                |           |                  |          |                     |           |            |    |      |          |                |       |           |       |           |       |       |          |           |          |          |       |       |       |              |
| Weld x3 vacuum manifolds in-situ   | w       | x              | w         | x                |          |                     |           |            |    | vor  | nnl      | $ \land \land$ | f     | har       | nair  |           | on /  | nvia  | otin     | 2         |          |          |       |       |       |              |
| Inspect welds of IFS vacuum manifolds  | н       | x              | н         | X                | н        | x                   |           |            |    | vai  | npl      |                |       | iai       | iyii  | iy e      |       |       | วนม      | y         |          |          |       |       |       |              |
| DFX pressure testing   |         |                |           |                  |          |                     |           |            |    |      | -        |                |       |           | 0     | •         |       |       |          | -         |          |          |       |       |       |              |
| Perform pressure test at room temperature and 4.9 bar applied to DFX helium vessel                 | N       | x              | N         | x                | N        | x                   |           |            | 29 | scir | gnm      | nen            | ht.   |           |       |           |       |       |          |           |          |          |       |       |       |              |
| Review pressure test data  | N       | x              | N         | X                | N        | x                   | 1         |            | a  | 2016 | 51 II I  |                | ιι.   |           |       |           |       |       |          |           |          |          |       |       |       |              |
|  | 11 1    |                |           |                  |          |                     |           |            | X۰ | -ray | y of     | to             | p d   | lorr      | ne t  | o b       | otto  | om    | do       | me        |          |          |       |       |       |              |
|  |         |                |           |                  |          |                     |           |            |    |      | •        |                | -     |           |       |           |       |       |          |           |          |          |       |       | A     |              |



### **F&I (REVIEW Points)**

A **REVIEW** point: = A review of the quality plan and could be integrated as part of a joint project meeting with all parties

A total of 8 REVIEW points (R) have been introduced into the DFX F&I schedule

|                        | HL-HLC: QUALITY - Manufacturing and Inspection   | Pla      | n for DFX         | Cry      | /ostat <mark>(</mark> SH | HOR       | T OVEF          | <b>VIEV</b> | V)         |   |        |        |          |          | D       | FX P         | roto          | - Pr     | oduc       | ction         | ı Plar  | n        |               |          |        |
|------------------------|--|----------|-------------------|----------|--------------------------|-----------|-----------------|-------------|------------|---|--------|--------|----------|----------|---------|--------------|---------------|----------|------------|---------------|---------|----------|---------------|----------|--------|
| Prepared<br>Date: 26-0 | by: W. Bailey, Y.Yang<br>32-2020   | Item     | Eq. Code:         |          |                          | As        | set Code: (L    | .HC Part I  | dentifier) |   | 2)     | 4)     | 1-2)     | 4)       | 1-2)    | 3-4)         | 1-2)          | 4)       | 1-2)       | 3-4)          | -2)     | -4)      | 1-2)          | 4)       | 1-2)   |
| Verfied by<br>Date:    | :  | Item     | description: DF)  | ( Cryo   | ostat (Proto)            | EC        | OMS Report      | No: 2337    | 7452       |   | EEK 1- | EEK 3- | (WEEK 1- | (WEEK 3- | (WEEK 1 | 2020 (WEEK 3 | 2020 (WEEK 1- | (WEEK 3- | 2020 (WEEK | (WEEK         | (WEEK 1 | (WEEK 3. | (WEEK 1-      | (WEEK 3- | EE     |
| Approved               | by:  | <u> </u> |                   |          |                          |           |                 |             |            |   | 3      | 3      | ≥.       | 3        | 3       | 3            | 2             | 3        | 2          | 2             | 3       | 3        | <u>s</u>      | <u>s</u> | 3      |
| Date:                  |  |          |                   | le: Asse |                          |           |                 |             |            |   | 2      | 2      | 20       | 8        | 20      | 5            | ្ត            | 2        | 00         | 2020          | 5       | 50       | 8             | 8        | ୍ଷ 🛛   |
| Na                     | A shirts   | Man      | ufacturer/Control | Institu  | ite / Verification en    | nt/3rd Pa | arty / Surveila | Rev. Doc.   | Notes      |   | r 2020 | r 2020 | ny 2020  | ıy 2020  | ie 2020 | 1e 20        | y 202         | y 2020   | August 2   | *             | ot 2020 | ept 2020 | it 2020       | t 2020   | v 2020 |
| INO.                   | Activity   |          | <i>c</i> /p.      | <u>.</u> | e                        |           |                 | ╞───┘       |            |   | Apr    | Ap     | Ma       | May      | Jun     | June         | ylut          | лı       | any        | Ingu          | Sep     | Sel      | ö             | Ö        | 2      |
|                        |  | Code     | Signature/Date    | Code     | Signature/Date C         | Code Sig  | gnature/Date    | L'          |            |   |        |        |          |          |         |              |               |          | 4          | 4             |         |          |               |          |        |
|                        | Procurement of materials/off-shelf components/bellows/flexibles                                | -        |                   | _        |                          |           |                 | <u> </u> '  |            |   |        |        |          |          |         |              |               |          |            |               |         |          |               |          | /      |
| 0.03                   |  | ĸ        | ×                 | R        | X                        |           |                 | <u> </u> '  |            | - |        |        |          |          |         |              |               |          |            |               |         |          | $\rightarrow$ |          |        |
|                        | Completion of procurement of 3D forged round plates and billets<br>Manufacturing of top flange | ĸ        | X                 | к        | ×                        |           |                 | <u> </u> '  |            | - |        |        |          |          |         |              |               |          |            |               |         |          |               |          |        |
| 1.13                   |  | D        | ×                 | P        | v                        |           |                 | <u> </u> '  |            |   |        |        |          |          |         |              |               |          | +          | $\rightarrow$ | +       |          | +             |          |        |
|                        | Manufacturing of other ancillaries for top dome + top flange assembly                          | n.       | ň                 |          | ~                        |           |                 | <u> </u> '  |            | - |        |        |          |          |         |              |               |          |            | $\rightarrow$ |         |          |               |          |        |
| END                    |  | R        | x                 | R        | x                        |           |                 | L           |            |   |        |        |          |          |         |              |               |          |            |               |         |          |               |          |        |
| 9.00                   | Manufacturing of "cold" elbow  |          |                   |          |                          |           |                 |             |            |   |        |        |          |          |         |              |               |          |            |               |         |          |               |          |        |
| 9.43                   |  | R        | x                 | R        | x                        |           |                 |             |            |   |        |        |          |          |         |              |               |          |            |               |         |          |               |          |        |
| 14.00                  | Manfacturing of combined top + mid-section assembly to lower elbow + VV cross assembly         |          |                   |          |                          |           |                 |             |            |   |        |        |          |          |         |              |               |          |            |               |         |          |               |          |        |
| END                    | Intermediate review point  | R        | x                 | R        | x                        |           |                 |             |            |   |        |        |          |          |         |              |               |          |            |               |         |          |               |          |        |
| 21.00                  | Manufacture of cold horizontal IFS section   |          |                   |          |                          |           |                 |             |            |   |        |        |          |          |         |              |               |          |            |               |         |          |               |          |        |
| 21.32                  |  | R        | x                 | R        | X                        |           |                 |             |            |   |        |        |          |          |         |              |               |          |            |               |         |          |               |          |        |
| _                      | Manufacturing of cold IFS section with VV IFS section  |          |                   |          |                          |           |                 | <u> </u> '  |            |   |        |        |          |          |         |              |               |          |            |               |         |          |               |          |        |
| END                    | Intermediate review point  | R        | x                 | R        | x                        |           |                 |             |            |   |        |        |          |          |         |              |               |          |            |               |         |          |               |          |        |



### F&I (SOTON Points)

A SOTON point: = An activity that is led by SOTON on LTi Metaltech site.

These include activities such as "applying MLI" and performing the electrical testing of heaters

A total of 15 SOTON points (S) have been introduced into the DFX F&I schedule

| н                | L-HLC: QUALITY - Manufacturing and Inspection Plan for   | DF   | Cryostat          | : <b>(</b> SI | HORT OV            | /ER    | RVIEW)              |          |            |            |            | C          | )FX F      | roto       | o - Pi     | odu        | ctior      | n Pla      | n         |          |            |          |          |
|------------------|--|------|-------------------|---------------|--------------------|--------|---------------------|----------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|-----------|----------|------------|----------|----------|
|                  | ad by: W. Bailey, Y. Yang<br>6-02-2020   | Item | Eq. Code:         |               |                    |        | Asset Code: (L      | 1-2)     | 3-4)       | 1-2)       | 3-4)       | 1-2)       | 3-4)       | 1-2)       | 3-4)       | 1-2)       | 3-4)       | 1-2)       | 3-4)      | 1-2)     | 3-4)       | 1-2)     | 3-4)     |
| Verfied<br>Date: | by:  | Item | description: DF)  |               | ostat (Proto)      |        | EDMS Report         | EK 1-    | EK 3-      | EK 1       | EK 3       | EK 1       | EK 3       | EK 1-      |            | 2020 (WEEK | 2020 (WEEK |            | EK 3      | EK 1-    |            | EK 1-    | EK 3-    |
| Approv           | ed by:   |      |                   |               |                    |        |                     | (WEEK    | 2020 (WEEK | 2020 (WEEK | 2020 (WEEK | 2020 (WEEK | 2020 (WEEK | 2020 (WEEK | 2020 (WEEK | 20         | × 0        | 2020 (WEEK | (WEEK     | (WEEK    | 2020 (WEEK | (WEEK    | (WEEK    |
| Date:            |  |      |                   |               | nspection          |        |                     | 8        | 2          | 2          | 2          | 2          | 2          | 2          | 2          | 8          | 8          | 2          | 2         | 0        | 9          | 2        | 2        |
| No.              | Activity   | Mar  | ufacturer/Control | Instit        | ute / Verification | ent/3r | rd Party / Surveila | Apr 2020 | Apr 202    | May 20:    | May 20     | June 20    | June 20    | July 202   | July 202   | August 2   | August 2   | Sept 20    | Sept 2020 | Oct 2020 | Oct 202    | Nov 2020 | Nov 2020 |
|                  |  | Code | Signature/Date    | Code          | Signature/Date     | Code   | Signature/Date      | Ā        | A          | Σ          | Σ          | 'n         | 7          | 'n         | 3          | Aug        | Aug        | Se         | Se        | ō        | 0          | ž        | ž        |
|                  | 00 Procurement of materials/off-shelf components/bellows/flexibles                             |      |                   |               |                    |        |                     |          |            | _          |            |            |            |            |            |            |            |            |           |          |            |          |          |
| 7.0              | 00 Manufacturing of mid-section sub-assembly   |      |                   |               |                    |        |                     |          |            |            |            |            |            |            |            |            |            |            |           |          |            |          |          |
| 7.3              | Insert MLI blanket between VB cage support and VV mid-section wall                             | S    | X                 | 5             | X                  |        |                     |          |            |            |            |            |            |            |            |            |            |            |           |          |            |          |          |
| 7.3              | Insert MLI blanket between VB membrane and cage support  | S    | X                 | 5             | X                  |        |                     |          |            |            |            |            |            |            |            |            |            |            |           |          |            |          |          |
| 7.4              | 14 Install heater + thermometer plate + wiring loom  | S    | X                 | S             | X                  |        |                     |          |            |            |            |            |            |            |            |            |            |            |           |          |            |          |          |
| 7.4              | 15 Perform electrical test and record data   | S    | x                 | S             | x                  |        |                     |          |            |            |            |            |            |            |            |            |            |            |           |          |            |          |          |
| 9.0              | 0 Manufacturing of "cold" elbow  |      |                   |               |                    |        |                     |          |            |            |            |            |            |            |            |            |            |            |           |          |            |          |          |
| 9.3              | 89 Fix heater mounting plates to bottom elbow flange   | 5    | x                 | S             | x                  |        |                     |          |            |            |            |            |            |            |            |            |            |            |           |          |            |          |          |
| 9.4              | Install heater and thermometer and route wiring loom   | 5    | x                 | 5             | X                  |        |                     |          |            |            |            |            |            |            |            |            |            |            |           |          | []         |          |          |
| 9.4              | 12 Apply MLI to "cold" elbow   | 5    | x                 | 5             | X                  |        |                     |          |            |            |            |            |            |            |            |            |            |            |           |          |            |          |          |
| 11.0             | 0 Manufacturing of top dome + top flange assembly  |      |                   |               |                    |        |                     |          |            |            |            |            |            |            |            |            |            |            |           |          |            |          |          |
| 11.3             | Apply MLI blankets to top dome and complete wraps to vertical tube walls                       | 5    | x                 | S             | X                  |        |                     |          |            |            |            |            |            |            |            |            |            |            |           |          |            |          |          |
| 19.0             | 00 Manufacture of "cold" horizontal sliding sleeve REAL PART                                   |      |                   |               |                    | 1      |                     |          |            |            |            |            |            |            |            |            |            |            |           |          |            |          |          |
| 19.1             | 16 Apply MLI blanket for tube section  | 5    | x                 | S             | x                  | 1      |                     |          |            |            |            |            |            |            |            |            |            |            |           |          |            |          |          |
| 21.0             | 00 Manufacture of cold horizontal IFS section  |      |                   |               |                    | 1      |                     |          |            |            |            |            |            | -          |            |            |            |            |           |          |            |          |          |
| 21.3             | 30 Apply MLI blanket to tubular assembly   | S    | x                 | S             | x                  |        |                     |          |            |            |            |            |            |            |            |            |            |            |           |          |            |          |          |
| 21.3             | Apply MLI to IFS wiring assemblies   | 5    | x                 | S             | x                  |        |                     |          |            |            |            |            |            |            |            |            |            |            |           |          |            |          |          |
| 21.3             | 39 Install MLI to reducer flange   | 5    | x                 | 5             | x                  |        |                     |          |            |            |            |            |            |            |            |            |            |            |           |          |            |          |          |
| 21.4             | 10 Tie down vacuum manifolds of each IFS wiring assembly for further operations                | S    | x                 | 5             | x                  |        |                     |          |            |            |            |            |            |            |            |            |            |            |           |          |            |          |          |
| 32.0             | 0 Manufacturing of DFX for pressure test   |      |                   |               |                    |        |                     |          |            |            |            |            |            |            |            |            |            |            |           |          | 1          |          |          |
| 32.0             | 01 Install and check additional instrumentation (strain gauging and load sesnors) to DFX Proto | S    | x                 | 5             | x                  |        |                     |          |            |            |            |            |            |            |            |            |            |            |           |          |            |          |          |
| 33.0             | 0 DFX pressure testing   |      |                   |               |                    |        |                     |          |            |            |            |            |            |            |            |            |            |            |           |          |            |          |          |
|                  | 2 Collect pressure test data from additional instrumentation                                   | 5    | x                 | 5             | x                  |        |                     |          |            |            |            |            |            |            |            |            |            |            |           |          |            |          |          |



DFX (proto) PRR – 03 MAR 2020

### **Component procurement plan**



### **Procurement plan summary**

- SOTON will contract LTi Metaltech to use their own list of approved suppliers to procure material/components to specification
- SOTON will assist LTi Metaltech with the procurement of certain materials/components to meet specification
  - Sheet metal/billets that satisfy < 0.1 % Cobalt content requirement\*</li>

\*It has been proposed that sheet material or billets could be procured from the same known batch and several samples produced for material testing of Cobalt content to confirm compliance

- 3-D forged plates in stainless steel grade 316LN for any lip welded flanges part of the helium vessel (Abbey Forged Product)
- Bellows fabricated to custom sizes, welded with radial lip welds and fabricated from SS grades from the approved list (Kompaflex)
- Flexible convoluted tubes fabricated from SS grades from the approved list (Kompaflex)
- If SOTON find it difficult to source any of the items listed above (especially within sensible budgets/leadtime), SOTON may place a request for CERN to assist with supply or materials/components from stores or own network of suppliers.



DFX (proto) PRR – 03 MAR 2020

### **Production schedule and associated resource**



#### DFX PRR (Proto) – 03 MAR 2020

### **Production schedule overview**

|       |  |                     |                     |                     |                     | D                    | FX F                 | Proto                | o - Pr               | odu                    | ctior                  | n Pla                | n                    |                     |                     |                     |                     |
|-------|--|---------------------|---------------------|---------------------|---------------------|----------------------|----------------------|----------------------|----------------------|------------------------|------------------------|----------------------|----------------------|---------------------|---------------------|---------------------|---------------------|
| No    | A +ti vitre  | Apr 2020 (WEEK 1-2) | Apr 2020 (WEEK 3-4) | May 2020 (WEEK 1-2) | May 2020 (WEEK 3-4) | June 2020 (WEEK 1-2) | June 2020 (WEEK 3-4) | July 2020 (WEEK 1-2) | July 2020 (WEEK 3-4) | August 2020 (WEEK 1-2) | August 2020 (WEEK 3-4) | Sept 2020 (WEEK 1-2) | Sept 2020 (WEEK 3-4) | Oct 2020 (WEEK 1-2) | Oct 2020 (WEEK 3-4) | Nov 2020 (WEEK 1-2) | Nov 2020 (WEEK 3-4) |
| NO.   | Activity   | AF                  | AF.                 | Σ̈́                 | Σ̈́                 | Ju                   | , a                  | 3                    | 3                    | Aug                    | Aug                    | Se                   | Se                   | ŏ                   | ŏ                   | ž                   | ž                   |
|       |  |                     |                     |                     |                     |                      |                      |                      |                      |                        |                        |                      |                      |                     |                     |                     |                     |
| 0.00  | Procurement of materials/off-shelf components/bellows/flexibles                        |                     |                     |                     |                     |                      |                      |                      |                      |                        |                        |                      |                      |                     |                     |                     |                     |
| 1.00  | Manufacturing of top flange  |                     |                     |                     |                     |                      |                      |                      |                      |                        |                        |                      |                      |                     |                     |                     |                     |
| 2.00  | Manufacturing of cryogenic insertion   |                     |                     |                     |                     |                      |                      |                      |                      |                        |                        |                      |                      |                     |                     |                     |                     |
| 3.00  | Manufacturing of top dome assembly   |                     |                     |                     |                     |                      |                      |                      |                      |                        |                        |                      |                      |                     |                     |                     |                     |
| 4.00  | Manufacturing of other ancillaries for top dome + top flange assembly                  |                     |                     |                     |                     |                      |                      |                      |                      |                        |                        |                      |                      |                     |                     |                     |                     |
| 5.00  | Manufacturing of outer fountain assembly   |                     |                     |                     |                     |                      |                      |                      |                      |                        |                        |                      |                      |                     |                     |                     |                     |
| 6.00  | Manufacturing of inner fountain components   |                     |                     |                     |                     |                      |                      |                      |                      |                        |                        |                      |                      |                     |                     |                     |                     |
| 7.00  | Manufacturing of mid-section sub-assembly  |                     |                     |                     |                     |                      |                      |                      |                      |                        |                        |                      |                      |                     |                     |                     |                     |
| 8.00  | Manufacturing of additional vertical vacuum vessel components                          |                     |                     |                     |                     |                      |                      |                      |                      |                        |                        |                      |                      |                     |                     |                     |                     |
| 9.00  | Manufacturing of "cold" elbow  |                     |                     |                     |                     |                      |                      |                      |                      |                        |                        |                      |                      |                     |                     |                     |                     |
| 10.00 | Manufacturing of lower VV cross section  |                     |                     |                     |                     |                      |                      |                      |                      |                        |                        |                      |                      |                     |                     |                     |                     |
| 11.00 | Manufacturing of top dome + top flange assembly  |                     |                     |                     |                     |                      |                      |                      |                      |                        |                        |                      |                      |                     |                     |                     |                     |
| 12.00 | Manufacturing of top dome + top flange assembly with mid-section assembly              |                     |                     |                     |                     |                      |                      |                      |                      |                        |                        |                      |                      |                     |                     |                     |                     |
| 13.00 | Manfacturing of "cold" elbow + VV cross section  |                     |                     |                     |                     |                      |                      |                      |                      |                        |                        |                      |                      |                     |                     |                     |                     |
| 14.00 | Manfacturing of combined top + mid-section assembly to lower elbow + VV cross assembly |                     |                     |                     |                     |                      |                      |                      |                      |                        |                        |                      |                      |                     |                     |                     |                     |
| 15.00 | Manufacture of cold horizontal section 1   |                     |                     |                     |                     |                      |                      |                      |                      |                        |                        |                      |                      |                     |                     |                     |                     |
| 16.00 | Manufacture of VV horizontal section 1   |                     |                     |                     |                     |                      |                      |                      |                      |                        |                        |                      |                      |                     |                     |                     |                     |
| 18.00 | Manufacture of "cold" horizontal sliding sleeve TEST                                   |                     |                     |                     |                     |                      |                      |                      |                      |                        |                        |                      |                      |                     |                     |                     |                     |
| 19.00 | Manufacture of "cold" horizontal sliding sleeve REAL PART                              |                     |                     |                     |                     |                      |                      |                      |                      |                        |                        |                      |                      |                     |                     |                     |                     |
| 20.00 | Manufacture of VV horizontal sliding sleeve  |                     |                     |                     |                     |                      |                      |                      |                      |                        |                        |                      |                      |                     |                     |                     | 1                   |
| 21.00 | Manufacture of cold horizontal IFS section   |                     |                     |                     |                     |                      |                      |                      |                      |                        |                        |                      |                      |                     |                     |                     |                     |
| 22.00 | Manufacture of VV horizontal IFS section   |                     |                     |                     |                     |                      |                      |                      |                      |                        |                        |                      |                      |                     |                     |                     | (                   |
| 23.00 | Manufacture of VV horizontal sleeve - plug end   | 1                   |                     |                     |                     |                      |                      |                      |                      |                        |                        |                      |                      |                     |                     |                     | 1                   |
|       | Manfacturing of additional parts for final assembly and testing                        | 1                   |                     |                     |                     |                      |                      | ·                    |                      |                        |                        |                      |                      |                     |                     |                     | 1                   |
|       | Manufacturing of cold horizontal section 1 to DFX vertical section                     |                     |                     |                     |                     |                      |                      |                      |                      |                        |                        |                      |                      | _                   |                     |                     | í .                 |
|       | Manufacturing of VV horizontal section 1 to DFX  |                     |                     |                     |                     |                      |                      |                      |                      |                        |                        |                      |                      |                     |                     |                     | í .                 |
|       | Manufacturing of cold sliding sleeve (TEST) with DFX                                   |                     |                     |                     |                     |                      |                      |                      |                      |                        |                        |                      |                      |                     |                     |                     |                     |
|       | Manufacturing of VV sliding sleeve with DFX  |                     |                     |                     |                     |                      |                      |                      |                      |                        |                        |                      |                      |                     |                     |                     |                     |
|       | Manufacturing of cold IFS section with VV IFS section                                  |                     |                     |                     |                     |                      |                      |                      |                      |                        |                        |                      |                      |                     |                     |                     |                     |
|       | Manufacturing of complete IFS assembly to DFX  |                     |                     |                     |                     |                      |                      |                      |                      |                        |                        |                      |                      |                     |                     |                     |                     |
|       | Manufacturing of VV plug end section to DFX  |                     |                     |                     |                     |                      |                      |                      |                      |                        |                        |                      |                      |                     |                     |                     |                     |
|       | Manufacturing of DFX for pressure test   |                     |                     |                     |                     |                      |                      |                      |                      |                        |                        |                      |                      |                     |                     |                     | 1                   |
|       | DFX pressure testing   |                     |                     |                     |                     |                      |                      |                      |                      |                        |                        |                      |                      |                     |                     |                     |                     |



### **Key points in production**

- 15 Hold points
- 24 Notified points
- 31 Witness points
- 8 Review points



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## **Production plan summary**

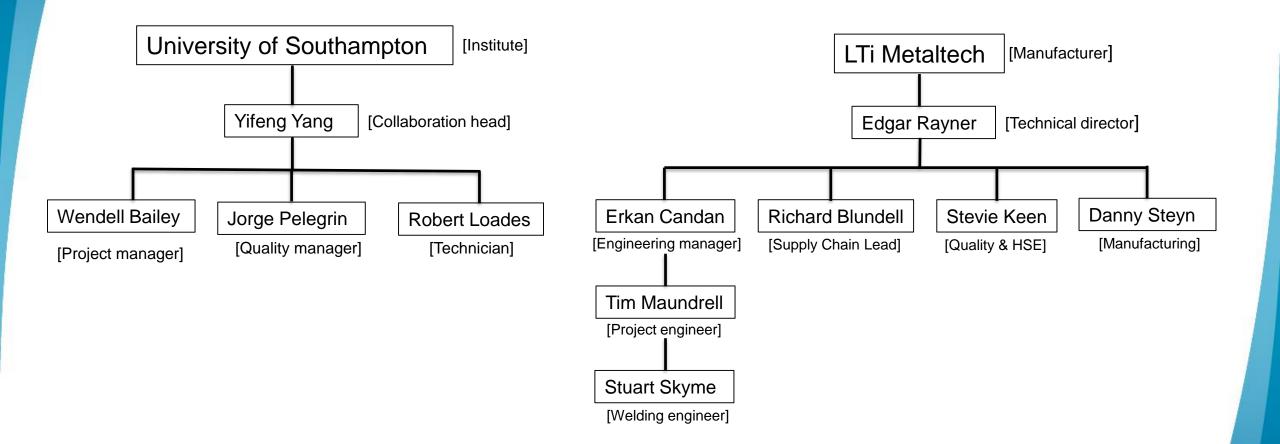
### Key milestones extracted from current production plan:

- Procurement phase (activity 0) = 8 weeks (1<sup>st</sup> Apr 31<sup>st</sup> May)
- Manufacturing of top flange assembly (activity 1) = 8 weeks (15<sup>th</sup> Apr 15<sup>th</sup> June)
- Manufacturing of top dome assembly (activity 3) = 10 weeks (1<sup>st</sup> May 15<sup>th</sup> July)
- Target delivery of heaters + thermometers by CERN (activity 7) (1<sup>st</sup> May 15<sup>th</sup> July)
- Manufacturing of mid-section assembly (activity 7) = 12 weeks (1<sup>st</sup> May 31<sup>st</sup> July)
- Manufacturing of top dome/flange + mid-section assembly (activity 12) = 2 weeks (15<sup>th</sup> July 31<sup>st</sup> July)
- Manufacturing of DFX vertical (activity 14) = 2 weeks (15<sup>th</sup> Sept 30<sup>th</sup> Sept)
- Target delivery of IFS by CERN (activity 21) = (1<sup>st</sup> July 15<sup>th</sup> July)
- Manufacturing of cold horizontal IFS section (activity 21) = 14 weeks (15<sup>th</sup> June 30<sup>th</sup> Sept)
- Manufacturing of VV horizontal IFS section (activity 22) = 8 weeks (1<sup>st</sup> July 15<sup>th</sup> July)
- Manufacturing of cold + VV horizontal IFS section (activity 29) = 2 week (1<sup>st</sup> Sept 15<sup>th</sup> Sept)
- Manufacturing of horizontal sub-assemblies to DFX vertical (activities 25-31) = 4 weeks (1<sup>st</sup> Oct 31<sup>th</sup> Oct)
- DFX full assembly pressure testing = (activity 32) 2 weeks (15<sup>th</sup> Nov 30<sup>th</sup> Nov)



DFX PRR (Proto) – 03 MAR 2020







DFX - 03 MAR 2020

# Appendix



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