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**Manufacturing Dossier-MD**

**55.QC - Ex-vessel material specification 01\_316L(N)-IG austenitic stainless-steel plates for Ex-Vessel Components**

This document is the material specification for the supply of 316L(N)-IG austenitic stainless-steel hot-rolled plates for ITER EQ#12 Ex-vessel components.

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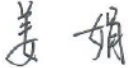


EXTERNAL REFERENCE

### Supplier Study/ Report

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<h2>55.QC Ex-vessel material specification.01_ 316L(N)-IG austenitic stainless-steel plates for Ex-Vessel Components</h2> <p><b>Abstract:</b> This document is the material specification for the supply of 316L(N)-IG austenitic stainless-steel hot-rolled plates for ITER EQ#12 Ex-vessel components.</p>			
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 CONTENT

<b>1</b>	<b>SCOPE</b> .....	<b>5</b>
<b>2</b>	<b>REFERENCED DOCUMENTS</b> .....	<b>5</b>
	2.1 DESIGN AND CONSTRUCTION CODE:.....	5
	2.2 EN AND ASTM STANDARDS:.....	5
<b>3</b>	<b>MELTING PROCESS</b> .....	<b>6</b>
<b>4</b>	<b>CHEMICAL REQUIREMENTS AND PHYSIC-CHEMICAL CHARACTERISTICS</b> .....	<b>6</b>
	4.1 REQUIRED VALUES.....	6
	4.2 CHEMICAL ANALYSIS.....	7
	4.3 FERRITE CONTENT AND MAGNETIC PERMEABILITY.....	7
	4.4 STRUCTURE.....	8
	4.4.1 Grain size.....	8
	4.4.2 Non-metallic inclusions.....	8
<b>5</b>	<b>MANUFACTURE</b> .....	<b>8</b>
	5.1 MANUFACTURE PROGRAMME.....	8
	5.2 DELIVERY CONDITIONS.....	9
	5.2.1 Solution heat treatment.....	9
	5.2.2 Pickling- passivation - surface conditions.....	9
<b>6</b>	<b>MECHANICAL PROPERTIES</b> .....	<b>9</b>
	6.1 REQUIRED VALUES.....	10
	6.2 SAMPLING.....	10
	6.2.1 Test procedure.....	10
	6.2.1.1 Tension testing at room temperature.....	10
	6.2.1.2 Tension testing at high temperature.....	12
	6.3 RETREATMENT.....	12
<b>7</b>	<b>SURFACE EXAMINATION-SURFACE DEFECTS</b> .....	<b>12</b>
<b>8</b>	<b>VOLUMETRIC EXAMINATION</b> .....	<b>13</b>
<b>9</b>	<b>REMOVAL OF UNACCEPTABLE AREAS</b> .....	<b>13</b>
	9.1 REMOVAL BY GRINDING.....	13

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9.2 REPAIR WELDING .....	14
10 DIMENSIONAL CHECK-TOLERANCES .....	14
11 MARKING.....	14
12 CLEANLINESS-PACKAGING-TRANSLATION.....	14
13 ACCEPTANCE .....	15
14 DOCUMENTATION AND TEST REPORT .....	15
15 QUALITY SYSTEM REQUIREMENTS.....	16
17 ACCESS OF INSPECTORS.....	16

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## 1 Scope

This specification covers 316L(N)-IG austenitic stainless-steel hot rolled plates between 5mm and 100mm thick for the ITER diagnostic 55. QC Ex-vessel zones, which include ISS (with structure in front of ISS: HELB etc....), Bio-shield and PCSS.

Generally, 316L(N)-IG steel is grade 316L steel with narrower alloying element ranges and controlled impurities. The closest analogy is X2CrNiMo17-12-2 controlled nitrogen content austenitic stainless steel described in the RCC-MR code, Edition 2007.

This Specification is based on the product procurement specification RM 3331 in RCC-MR 2007 and EN 10088-2 for plates, plus additional requirements arising from the features of the EQ#12 Ex-vessel components. The plates are considered for equipment Class 2 (in accordance with RCC-MR classification).

Thanks to the ITER PPD division, this specification based on their approved document [APPENDIX B1 03 Annex 1: Product Procurement Specification for the supply of 316L\(N\)-IG austenitic stainless steel plates for Ex-Vessel Components \(3V6AC8 v1.2\)](#).

The amount of stainless-steel plates to be procured shall include appropriate contingency to face unexpected difficulties, to remake rejected parts and to repair parts with insufficient quality.

The supply covers the following items:

- Manufacture of the total quantity of stainless-steel plates grade 316L(N)-IG.
- Organization of quality at works.
- Elaboration of all procedures required for the manufacturing, inspection (including analyses), packaging, storage and delivery.
- Time schedules and documentation.
- To perform all the inspections and tests during and after manufacturing envisaged in this specification.
- Storage, packaging and delivery.

## 2 Referenced documents

The following Codes and Standards shall be referred to in this specification:

### 2.1 Design and Construction Code:

- RCC-MR, Edition 2007.
- RCC-MR, 2007, Section 2 – Materials, Chapter RM 3331.
- Applicable requirements of RM 0100 of RCC-MR, Edition 2007 must be respected.

### 2.2 EN and ASTM Standards:

- [NF-EN 10088-2: 2005](#) Stainless steels. Technical delivery conditions for sheet/plate and strip of corrosion resisting steels for general purposes.

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- EN ISO 6892-1 Tensile testing at ambient temperature.
  - EN ISO 6892-2 Tensile testing at elevated temperature.
  - NF-EN 10307: 2002 Ultrasonic testing of austenitic and austenitic-ferritic stainless steels. Flat products of thickness equal to or greater than 6 mm.
  - NF-EN 10204: 2004 Metallic products: Type of inspection documents.
  - NF-EN 10029: 2011 Hot rolled steel plates 3 mm thick or above -Tolerances on dimensions, shape and mass.
  - NF-EN ISO 643: 2013 Steels - Micrographic determination of the apparent grain size.
  - ASTM E45-13 Standard test methods for determining the inclusion content of steel.
  - ASTM A342-14 Standard Test Methods for Permeability of Feebly Magnetic Materials.

EN, ISO and ASTM standards mentioned in this TS documents may be considered in their last revision at the time of the sign of the contract provided that equivalency is demonstrated.

In case of change of edition year or issuing standard, which supersede above mentioned, the use of new Standards is allowed only in case of demonstration of equivalency with prior written Client's approval.

The use of EN but non-NF Standards is also allowed demonstrating equivalence with the corresponding NF version of the Standard.

Other equivalent national or international standards and codes or internal standards/procedures proposed by the supplier may be acceptable with Client's approval, provided conformity assessment to all criteria is satisfied.

### **3 Melting process**

The steel shall be made using an electric furnace or by any other technically equivalent process.

For the ISS and PCSS application and to meet requirements for structure and inclusion contents in this specification the melting of steel shall be completed by a suitable secondary metallurgy treatment. The refining processes are argon-oxygen decarburization (AOD), vacuum oxygen de-carbonized (VOD).

Supplier shall propose refining method, which shall be agreed with the Client.

### **4 Chemical requirements and physic-chemical characteristics**

#### **4.1 Required values**

The chemical composition determined by ladle and product analyses, shall comply with the requirements given in Table 1. Maximum content of impurities (Co, Nb, Ta) to meet the [Chemical composition and impurity requirements for materials \(REYV5V v2.3\)](#).



Table 1. Chemical composition

Element	Alloying elements and impurities content, wt.%	
	Minimum	Maximum
C		0.030
Mn	1.60	2.00
Si		0.50
P		0.025
S		0.010
Cr	17.00	18.00
Ni	12.00	12.50
Mo	2.30	2.70
N	0.060	0.080
B		0.002
Cu		0.30
Co*		0.05
Nb*		0.01
Ti		0.10
Ta*		0.01
*Radiation protection requirements		

#### 4.2 Chemical analysis

The Steelmaker shall supply a ladle analysis certified by the Mill Manager or his duly accredited representative. In addition, they shall provide a product analysis taken from each rolled plate. This latter analysis may be performed on metal discards taken from mechanical test specimens.

Chemical analyses and crosschecks shall be performed in a laboratory of the steel manufacturer's choice, according to the laboratory's usual method. These analyses shall be performed in compliance with the requirements of RMC 1000 of RCC-MR 2007.

#### 4.3 Ferrite content and magnetic permeability

The ferrite content evaluated using the Schaeffler diagram, modified by Pryce and Andrews (Figure RMC 1341.2, Section 3, RCC-MR 2007) and measured on a solution annealed product must be less or equal than 0.5 %.

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The ferrite content shall be measured at the surface of each heat-treated rolling sheet or strip, at one quarter width at the top and bottom, close to mechanical test specimens. Method of testing is RMC 1340 of RCC-MR, Edition 2007 or by method agreed between the Client and the Supplier.

The relative magnetic permeability of the finished plates shall be measured at room temperature after solution annealing. The value measured shall be lower than or equal to 1.03 (for fields of over 80000 A/m (1000 Oe) as per Test method 2 or measured with a low  $\mu$  permeability indicator as per method 3 of ASTM A342-14. Specimen for testing shall be cut as described in the previous paragraph. Measurements of permeability made with other physical methods (e.g. permascope, magnetoscope, etc.) are accepted provided information about type and trade mark of apparatus uses and information about calibration.

#### **4.4 Structure**

A micrographic examination with photographs must be made parallel to the rolling direction of each heat-treated plate rolling sheet or strip. The structure must be homogeneous.

##### **4.4.1 Grain size**

The grain size number determined in accordance with NF-EN ISO 643:2013 shall be greater than 2. The grain size homogeneity shall be  $\pm 1$  around the true average value. The presence of a few grains of index 1 or 0 is tolerated.

The determination is performed on test samples taken from the immediate vicinity of the mechanical test specimens.

##### **4.4.2 Non-metallic inclusions**

Amount and definition shall meet standard ASTM E45-13.

Test shall be done from one edge of each heat-treated plate rolling sheet or strip.

Macro-inclusions (exogenous inclusions from entrapped slag or refractories): they are strictly forbidden and are cause of rejection.

The rate of shall be checked using the Method D (or equivalent) to be within the following inclusion limits:

- Inclusion Type A  $\leq 1.0$
- Inclusion Type B  $\leq 1.0$
- Inclusion Type C  $\leq 1.0$
- Inclusion Type D  $\leq 1.5$

## **5 Manufacture**

### **5.1 Manufacture programme**

Prior to the commencement of manufacturing operations, the material Supplier shall draw up a manufacturing programme. This programme shall include:

- 
- Identification of melting process.
  - Ingot weight and type.
  - Identification of main hot-working operations.
  - In case of continuing casting, the discard parameters, weight of blooms, etc.
  - Top and bottom end discard percentages.
  - Position of plate in the ingot, in particular the final rolling direction in relation to the ingot axis.
  - Indication of the main rolling direction.
  - Conditions for intermediate heat treatments and for final solution heat treatment (in particular, temperature, holding time and cooling method).
  - Position of acceptance test samples on the plate.
  - Dimensional drawing with position of test specimens in these samples.

The various heat treatments, sampling and non-destructive examination operations shall be presented in chronological order.

For plates less than 80 mm thick, points 2nd, 3rd and 5th of afore mentioned manufacturing programme are not required.

The program shall be agreed with the Client.

## **5.2 Delivery conditions**

The plates shall be delivered in a solution heat treated, pickled and passivated condition, equivalent to 1D finish according NF-EN 10088-2:2005.

### **5.2.1 Solution heat treatment**

Solution heat treatment shall consist of maintaining a temperature of between 1050°C and 1150°C followed by water cooling and possible air cooling for smaller thicknesses. The thermal cycles shall be recorded and the records kept shall be presented in the test report.

### **5.2.2 Pickling- passivation - surface conditions**

The pickling-passivation treatment shall be performed in compliance with the requirements of RF 6000. No trace of oil or grease must remain on the surface of the metal in the as-delivered condition.

The surface condition of the plates evaluated in accordance with defined by chapter 8.1 in IVH, that is, a roughness of not SIC-1 component is about 6.3 µm, it is also defined in accordance with in accordance with RMC 7200 of RCC-MR 2007. If in doubt, this comparative examination shall be supplemented by a measurement using a roughness meter. The result of this measurement should be  $\leq 9$  µm. Method of testing shall be proposed by Supplier and agreed with the Client. Roughness measurement in accordance with NF-EN ISO 4288:1998 can be used.

## **6 Mechanical properties**

## 6.1 Required values

Mechanical strength requirements shall comply with values given in Table 2.

Table 2. Mechanical properties

Tensile properties			
Test temperature(°C)	Tensile strength, (Rm)min (MPa)	Yield Strength (Rp0.2%) min (Map)	Elongation A, (5d) min (%)
Room	525-700	220	45
250	415	135	-

Note: Yield strength at 1% offset (Rp1.0%,) shall be given for information purposes as the tensile strength (Rm) for tension testing at high temperature.

## 6.2 Sampling

Test samples shall be taken after the plate has been subjected to solution heat treatment. They shall be appropriately marked and show the final rolling direction.

The size of test samples shall be such that they can provide enough test specimens for all test and retests. Test samples shall be taken halfway between the edge and the axis of the plate centerline. Specimens shall not be taken closer to the edge of the sample than a distance equal to the thickness of the plate. The longitudinal axis of the test specimens shall be parallel to the rolling skins and perpendicular to the final rolling direction.

The longitudinal axis for tension test specimens is located as follows:

- For plates 30 mm thick or less, at mid-thickness.
- For plates thicker than 30 mm, at quarter thickness
- For plates less than 10 mm thick, the thickness of the test specimen shall be equal to the thickness of the plate (specimen with rectangular cross-section).

The tests shall be performed on specimens taken from samples subjected to no heat treatment after sampling. The number of tests to be performed is given in Table 3.

### 6.2.1 Test procedure

#### 6.2.1.1 Tension testing at room temperature

##### Test specimen

Test specimens shall have a circular section. Their normal diameter shall be 10 mm and their dimensions as specified in Appendix D of NF-EN 10002-1:2001. For plates less than 20 mm thick, the cylindrical test specimen may be replaced by a specimen with a rectangular section. For details see RMC 1211 of RCC-MR 2007.

##### Test method:

The tension test shall be performed in compliance with NF-EN 10002-1:2001.

The following values shall be recorded:

- Yield strength at 0.2% offset, in MPa.
- Yield strength at 1% offset, in MPa.
- Ultimate tensile strength, in MPa.
- Percentage elongation after fracture.
- Percentage reduction of the area after fracture.

Table 3. Number of and content of test-sampling

Name of test	Test Temperature (°C)	Weight of plate	Thickness t	Top end			Bottom end			Number of specimens		
				Full thickness	Mid-thickness	Quarter thickness	Full thickness	Mid-thickness	Quarter thickness	Per heat	Per sheet	
<b>Solution heat treated (SHT)</b>												
Tensile	Room	< 3000 kg	< 10 mm	1								1
			10 mm ≤ t < 30 mm		1							1
			> 30 mm			1						1
			< 10 mm	1			1					2
			10 mm ≤ t < 30 mm		1			1				2
			> 30 mm			1			1			2
	250	Regardless of weight	< 10 mm	1							1	
			10 mm ≤ t < 30 mm		1						1	
			> 30 mm			1					1	
			< 10 mm	1							1	
			10 mm ≤ t < 30 mm		1						1	
			> 30 mm			1					1	

SHT-solution heat treated

### Results

The results obtained shall meet the requirements given in Table 2 (the percentage of area reduction and yield strength at 1% offset shall be given for information). If this is not the case and the test specimen has a physical defect (which does not affect the usefulness of the product) or if unsatisfactory test results are due to incorrect mounting of the specimen or a testing machine malfunction, the test shall be repeated using another specimen. If the results of the second test are satisfactory, the rolled sheet shall be accepted; if not, the following paragraph shall apply.

When unsatisfactory results cannot be attributed to any of the above-mentioned causes, two

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retests may be performed for each unsatisfactory result obtained. The second set of test specimens shall be compared to the defective ones. If the results of the retest are satisfactory, the rolled sheet shall be accepted; if not, it shall be rejected, see chapter "Retreatment".

### **6.2.1.2 Tension testing at high temperature**

#### **Test specimen**

The nominal diameter shall be 10 mm. The dimensions are as specified in NF-EN 10002- 5:1992. For plates less than 20 mm thick, the cylindrical test specimen may be replaced by a specimen with a rectangular section. For details see RMC 1212 of RCC-MR 2007.

#### **Test method:**

The tension test shall be performed in compliance with NF-EN 10002-5:1992. The rate of stressing shall not exceed 80MPa per minute up to the yield strength. For details see RMC 1212 of RCC-MR 2007.

#### **Results**

Yield strength at 0.2% offset obtained shall meet the requirements given in Table 2. If this not the case, the paragraph "Results" of chapter "Tension test at room temperature" shall be applied.

### **6.3 Retreatment**

Rolled plates rejected on the basis of unsatisfactory results for one or more mechanical tests may be retreated (solution heat treatment as per 5.2.1) Retreatment conditions shall be described in the test report.

In the case of rejection, test specimens shall be taken in the same condition as specified in chapter 6.2. Tests performed shall be the same as those described in chapter 6.2. Not more than one retreatment shall be allowed.

## **7 Surface examination-surface defects**

Plates shall be visually examined. Their surfaces shall be plain, uniform and free from wrinkles, buckles, blowholes, tears, cracks and inclusions.

After cutting to the delivery dimensions, the edges shall be visually examined in accordance with RMC 7100 of RCC-MR 2007. The absence of cleavage or lamination (for example comprised by a fine layer of inclusions drawn out during rolling) shall be checked. If in doubt, a liquid penetrant examination shall be performed in accordance with RMC 4000 of RCC-MR 2007, Penetrant also could refer DR (62DRWZ) launched by PI.

#### **Criteria:**

Indications with one dimension exceeding 1 mm shall be considered as a recordable condition. The following are acceptable:

- Linear indications of 8 mm or less for plates 40 mm thick or less, and of 10 mm or less

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for plates more than 40 mm thick.

- As the operating conditions of the plates could lead to a risk of lamellar tear, the only
- acceptable indications are those with a cumulative length over the most densely covered meter as follows:
  - ✓ Less than 30 mm for plates up to 40 mm thick.
  - ✓ Less than 40 mm for plates over 40 mm thick.

Two separate indications are considered as one if the distance between them is less than twice the length of the smaller of the two. The length of the indication is then equal to the sum of the length of the two indications plus the distance between them.

If these criteria are not respected, no repair welds shall be authorized and the part is rejected. However, if there are special and highly localized indications (which can be checked by shear wave ultrasonic examination) this zone can be eliminated by grinding and the plate accepted if its dimensions remain within the acceptable tolerances.

Note: if during use, cleavage or lamination appears, the plate shall be discarded.

## 8 Volumetric examination

**All plates shall be examined.** An ultrasonic examination shall be performed in compliance with RMC 2400 of RCC-MR 2007, which states the condition for application of standard EN 10307.

The examination shall only be carried out for parts at least 30mm thick, in accordance with the scanning plan and the criteria given in standard NF-EN 10307:2002, quality class S2 for plate body and quality class E3 for plate edges.

The scan plans utilized for the examination of the rolled plates shall be as a part of the final reports

## 9 Removal of unacceptable areas

### 9.1 Removal by grinding

The Supplier may remove surface defects by grinding, providing that:

- The remaining thickness is within the tolerances specified by the drawing or the purchase order.
- The cavity blends smoothly with the surrounding surface.

After removal, the surface is subject to liquid penetrant examination in accordance with RMC 4000 of RCC-MR 2007. Penetrant used could refer with DR (62DRWZ) launched by PI.

The following criteria shall be applied for the liquid penetrant examination. An indication greater than 1 mm shall be considered recordable conditions.

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The following are unacceptable:

- Linear indications.
- Rounded indications with one dimension greater than 2 mm.

## 9.2 Repair welding

As general rule, the Rolling Mill shall not be authorized to perform welding repairs.

## 10 Dimensional check-tolerances

Dimensional checks shall be performed following procedures and requirements of ordering information of the Technical Specification.

The dimensions of the plates shall comply with requirements of the purchase order. The tolerances for thickness, length, width, flatness, edge camber and out of squareness shall comply with NF-EN 10029:2011.

The following are requirements for tolerances:

- Thickness tolerance - Class C as in NF-EN 10029:2011.
- Flatness tolerances - Class S as in NF-EN 10029:2011.
- Edge camber shall be limited to 0.2% of the actual length of plate and out-of-squareness.
- limited to 1% of actual width (G), as specified in NF-EN 10029:2011.

## 11 Marking

The Supplier shall specify the identification and marking method used, in compliance with RC 1300 of RCC-MR 2007.

Each plate shall be legibly identified with the following information:

- Manufacturer name or symbol.
- Plate number or unique identification number related to quality history.
- Grade of material.
- Heat number.

Markings or codes which provide clear reference to documents containing the information required for production control will always be acceptable.

Samples delivered with the part shall be marked in accordance with provisions of the purchaser order.

## 12 Cleanliness-packaging-translation



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Requirements are specified in the purchase order, taking particular account the requirements of RF 6000 of RCC-MR 2007.

## 13 Acceptance

***Material Test Report and certificate have to be provided to the Purchaser prior to delivery. Material and certification shall be in compliance with this Specification. Material cannot be accepted if it does not comply with this Specification.***

### Certification

A certificate, that the material was manufactured, sampled, tested and inspected in accordance with requirements of the material Specification and has been found to meet those requirements shall be supplied to the purchaser.

## 14 Documentation and test report

The Supplier shall provide the Inspection Certificate type 3.1 in accordance with NF-EN 10204:2004.

The Inspection Certificate is accepted only provided the Material Manufacturer has an appropriate quality-assurance system, certified by a competent body established within the European Community and having undergone a specific acceptance for materials.

**Inspection certificate type 3.2 in accordance with NF-EN 10204:2004 can be provided by Supplier after agreement with the Client, providing justification that the Accepted Notified Body or another Authorized Third-Party Organization followed the testing as specified in accordance with NF-EN 10204:2004.**

The following reports shall be drawn up by the Supplier after each individual test and prior to the delivery of the part:

- Ladle and product analyses.
- Melting process method.
- Records of micrographic examination, inclusions and grain size.
- Ferrite content and permeability.
- Results of mechanical property tests.
- Non-destructive examination.
- Dimensional check and roughness.
- Record of heat treatment.

These reports shall include:

- Material designation and marking.
- The heat number and part reference number.
- Identification of the Supplier.
- Identification of the purchase order number.

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- Name of the Inspection Agency, where applicable.
  - Test and retest results together with required values.
  - Packaging data.

All documents shall be in the English language or Chinese-English bilingual and all measures shall be given in the metric system SI. Each document shall be provided as an electronic file in PDF format.

## **15 Quality system requirements**

The Supplier shall implement an adequate and currently operational quality control system capable of ensuring that:

- Contract requirements will be met.
- Evidence of such compliance will be maintained.

The quality control system implemented by the Supplier shall:

- Be based on recognized quality standards.
- Encompass all activities performed in connection with the contract.
- Be described in a manual to be submitted to the Client at the start of the work.

The Supplier shall ensure that each subcontractor implements an effective quality control system. Failing this, the Supplier shall undertake all necessary actions to establish and maintain quality control in the subcontractors' premises.

The quality organization shall comply with the requirements defined in the contract.

## **16 Access of inspectors**

Representatives of the Client and of Third-Party Inspectors (TPI) shall at reasonable notice have the right to check at the Supplier's premises or at those of the sub-contractor the progress and status of the work forming the subject matter of the procurement and to witness specified tests.

The Supplier shall hold at the disposal of the Client and TPI and make available to them such information and documents as are necessary to determine the progress and status of the work.