

NEK

Nuklearna elektrarna Krško
Vrbina 12
8270 Krško



TECHNICAL SPECIFICATION

IPB branch to T1&T2 unit transformers upgrade

KRŠKO NUCLEAR POWER PLANT

SP-E3058

Revision 0

Augumented Quality

Prepared by:

Marko Štibuhar

Date: 02 / 09 / 2026

Reviewed by:

Boštjan Pevec

Date: 02 / 09 / 2026

Reviewed by:

Damijan Gregorič

Date: 2 / 9 / 2026

Approved by:

Peter Jan

Date: 04 / 09 / 2026

TABLE OF CONTENTS

Section	Title Description	Page
1.0	SCOPE	1
2.0	DEFINITIONS AND ABBREVIATIONS	1
3.0	CODES STANDARDS AND REGULATORY REQUIREMENTS	1
4.0	SUPPLEMENTAL DATA	2
5.0	DOCUMENT SUBMITTAL	2
6.0	DESIGN REQUIREMENTS AND DESIGN INPUTS	2
7.0	PERFORMANCE REQUIREMENTS	4
8.0	MATERIAL REQUIREMENTS	5
9.0	FABRICATION AND ASSEMBLY	5
10.0	INSPECTION AND TEST	5
11.0	ITEM QUALIFICATION	6
12.0	CLEANING	6
13.0	CORROSION PROTECTION / COATING	7
14.0	MARKING AND IDENTIFICATION	7
15.0	PACKAGING, HANDLING AND STORAGE	7
16.0	NONCONFORMING MATERIALS	7
17.0	RECORDS	7
18.0	OTHER REQUIREMENTS	8
19.0	RIGHT OF ACCESS	8
20.0	QA PROGRAM REQUIREMENTS	8
21.0	SPECIAL HANDLING	8
22.0	SHELF LIFE	8
23.0	10CRF21 REPORTING (For US supplied equipment only)	8
24.0	COMMERCIAL GRADE DEDICATION	8
25.0	SUPPLIER DOCUMENTATION REQUIREMENTS	9
26.0	NEK PROPRIETARY DATA	9
27.0	NON-CONFORMANCE REPORTS	10
28.0	REPAIR RECORDS	10
29.0	SOURCE INSPECTION / SURVEILLANCE NOTIFICATION	10
30.0	SHIPPING REQUIREMENTS	10
31.0	DELIVERY SCHEDULE	10
32.0	HOLD POINTS	11
33.0	VENDOR TECHNICAL MANUAL AND REGISTERED UPDATES	11
34.0	TRAINING	11
35.0	ATTACHMENTS	11

1.0 SCOPE

1.1 Scope of Work

This specification establishes the information required by manufacturers to submit bids for the design, fabrication and delivery of upgraded IPB branch to T1&T2 unit transformers.

Supplier shall be responsible for compliance with all the detailed requirements presented in this Specification. Supplier is responsible for performing, in addition to the requirements of this Specification, such analyses, tests, inspections, and other activities, which the Supplier considers necessary to ensure that the design, material, and workmanship are satisfactory for the material, or as may be required by common usage or good practice.

1.2 Equipment, Material and Service to be furnished by the Contractor

Contractor shall provide the following equipment

- Fully assembled upgraded IPB branch to T1&T2 unit transformers (with minimal as possible welding on site)
- Site supervisor present on site during IPB branch upgrade

2.0 DEFINITIONS AND ABBREVIATIONS

2.1 Definitions

E&DC	Engineering and Design Change
NCR	Nonconformance Report
NEK	Nuklearna elektrarna Krško (Nuclear Power Plant Krško)
RFQ	Request for Quotation
FAT	Factory acceptance test
T1	Auxiliary Transformer T1 (designation XR101XFR001)
T2	Auxiliary Transformer T2 (designation XR101XFR002)
IPB	Isolated Phase Bus

3.0 CODES STANDARDS AND REGULATORY REQUIREMENTS

All equipment to be furnished under this Specification shall conform to portions of the following codes as applicable.

1. ANSI/IEEE C37.23 Standard for metal-enclosed bus and calculating losses in isolated-phase bus
2. ANSI C29.9 For wet-process porcelain insulators (apparatus, post type)
3. ANSI C37.5 Guide for calculation of fault current...
4. ANSI C37.24 Guide for evaluating the effect of Solar Radiation on outdoor Metal-Clad Switchgear
5. DIN EN 60865-1 / IEC60865-1: Basis for calculation of the short circuit strength of bus bars.
6. DIN 40501 for mechanical data of used conductor profile within Section E (unit transformers T1/T2)

Any conflict between the above requirements and those specified herein shall be reported to the NEK for interpretation. Contractor shall be responsible for compliance with all applicable codes and regulations. The NEK will accept only material and equipment which meets the criteria of this Technical Specification and the referenced codes and standards.

4.0 SUPPLEMENTAL DATA

The replacement equipment is intended for installation on existing Isolated Phase Bus Section E connecting Unit Transformers T1 and T2 to the 21 kV generator bus system.

The existing IPB system is a Westinghouse force-cooled isolated phase bus system originally designed for 21 kV and 24,000 A operation. The modified branch sections shall be compatible with all existing interfaces and adjacent IPB equipment.

The existing support structures should be re-used whenever possible. New structural supports are not included unless required by Supplier calculations and approved by NEK.

5.0 DOCUMENT SUBMITTAL

All documentation shall be submitted to the NEK purchasing department referent to the address:

Nuklearna Elektrarna Krško
Vrbina 12
8270 Krško, Slovenia, EU

All document submitted to NEK shall be in form of hard copy and electronic media and must include Purchase Order Number, Equipment Tag Number and Supplier Shop Order Number. Electronic media shall be in format fully compatible with the following software:

- | | |
|---------------------------|--------------------------------------|
| a. Text documents: | Microsoft Word or Adobe Acrobat |
| b. Electronic mail: | Microsoft Outlook or compatible |
| c. Spreadsheets: | Microsoft Excel or Access |
| d. Drawings: | AutoCAD |
| e. Planning & Scheduling: | Microsoft Project or Microsoft Excel |

NEK shall approve use of any other electronic format. Preferred paper size for drawings is A2 or smaller, A3 or A4 should be used whenever is possible.

6.0 DESIGN REQUIREMENTS AND DESIGN INPUTS

NPP Krško will upgrade the T1 & T2 unit transformers' connection branches of the Isolated Phase-Bus (IPB) system to increase their short circuit (SC) current withstand capability and elevate the transmission ability to the highest possible level.

The IPB transmits power from 880MVA, 0.872 PF, 767MW generator through two parallel-connected 500MVA step-up transformers, to 400kV power grid. Additionally, it feeds the internal 6,3kV grid through two 30MVA unit transformers.

The IPB system at the NPP Krško was designed and manufactured by Westinghouse DED in mid-1970s and has been in operation since the early 1980s.

The system's design is based on 813 MVA generator that feeds two parallel- connected 375MVA step-up transformers and two 30MVA unit transformers. Section A of the system,

which carries high current, is force cooled while the branches (sections B, C, D and E) are self-cooled (Figure 1).

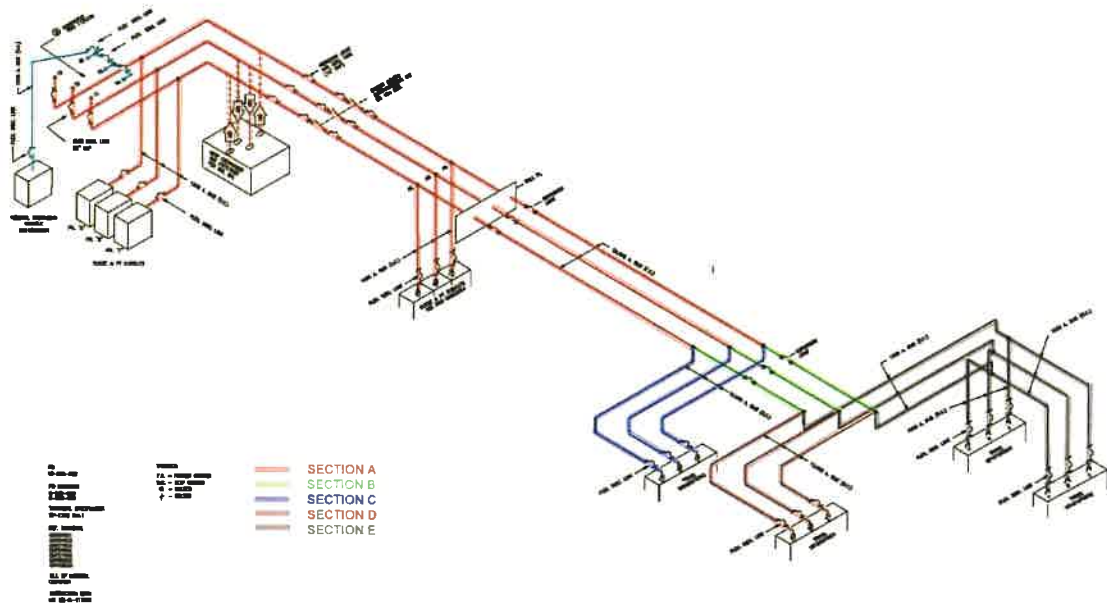


Figure 1: IPB sections overview

The plant modernizations and power up rates of several components/systems, including the main generator, have exposed the IPB to loads different from those originally designed, causing it to challenge certain designed limits.

As a part of the main generator stator replacement contract, Siemens AG (SIE) performed an IPB design and performance analysis under new conditions. The SIE IPB Study Revision F, Reg. No. 715001, issued in October 2009, identified the potential weak points of original design when exposed to new operating conditions while considering the IPB in as-new condition i.e. ageing was not considered in the study.

The results of this IPB Study Rev. F were required to be independently reviewed and calculations verified using the original Westinghouse design methodology.

The original equipment manufacturer (OEM), Westinghouse Electric Company DED – Cincinnati, facility was closed in 1986. The acquired intellectual property and legal rights, as well as assets from Westinghouse were transferred to Crown Electric (CRW). The CRW, as the OEM successor, was contracted in 2009 to perform the independent engineering evaluation of IPB under uprated operating conditions using the original Westinghouse design methodology.

The CRW Final Report IPB-CRW-NEK-006 was issued in December 2010. It considered the IPB operation under new uprated conditions and provided recommendations for improvement. The CRW crew field inspected IPB and the associated cooler actual service condition. The findings are covered in Inspection Report IPB-CRW-NEK-007 concluding that IPB as well as the cooler are in good operating conditions and not affected by aging.

The recommendations given in the abovementioned studies have already been implemented by now with exception to insufficient short circuit current withstand capability of T1 & T2 branch connections which is covered by this specification.

7.0 PERFORMANCE REQUIREMENTS

NPP Krško IPB is Westinghouse DED - Force Cooled, 21 kV, 24000 A, Continuous Housing Design, originally designed, manufactured, delivered and installed per:

Purchase order: 13-KRA-032-SG
 General order: ZEIA-11006
 Technical spec.: SP-E305 Rev.1, 1975, Gilbert
 Instruction Book: I.B. ZE-IA-11006, August 1979, (W) DED
 Tag No.: GN105BUS
 (W) Layout DWG: CN7D7001, CN7D7002 and CN7D7003

The simplified layout of the IPB (Figure 2) will be used as a supplement to the IPB layout drawings for specific IPB area or components identification within this document.

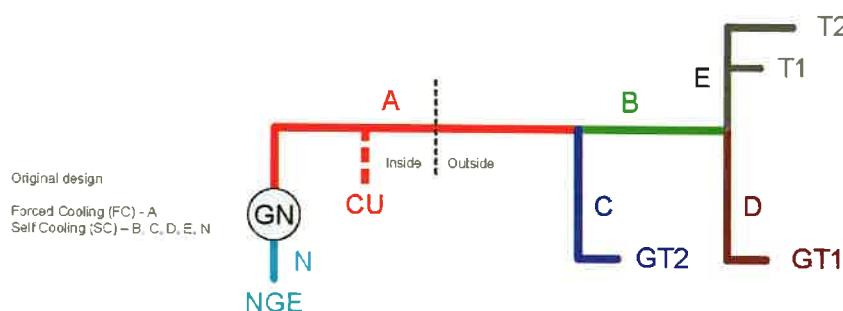


Figure 2: The simplified layout of the IPB

Section E (Figure 2) is made of 4x1,75 inch channel conductor (see Figure 3).

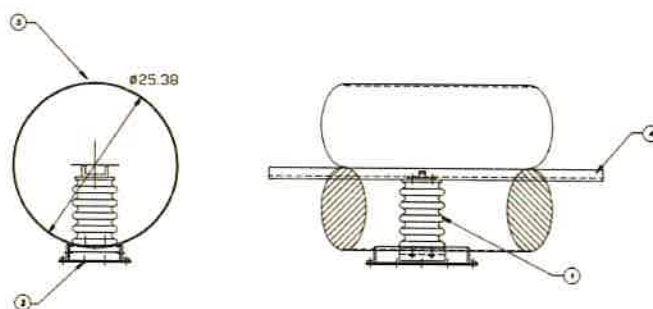


Figure 3: The existing 1,5kA IPB detail

The existing conductor is of adequate capacity to carry continuous load current to T1 & T2 however, it is subject to much higher current in short circuit conditions when the Peak Current at $t=0s$ is $I_{peak} = 775,29 \text{ kA}$.

Due to such a current, the conductor is exposed to a large bending force, particularly at the elbow. The channel shaped conductor has insufficient cross section to withstand such current.

The support insulators are also exposed to cantilever forces close to their maximum cantilever strength in existing configuration.

Additionally, a high SC current flow for 200 ms will increase the temperature of conductor over 70°C which is higher than the standard allows.

Modification 1012-GN-L will redesign and upgrade the original IPB section E to unit transformers T1 & T2 to match the plant uprated power output in all operating conditions.

To improve IPB section E short circuit current withstand capability it is necessary to:

1. The 4x1,75'' channel conductor of section E must be redesigned and replaced. The 3,5'' OD cylindrical conductor is bigger in cross section, but small enough to fit into existing enclosure (see Figure 2).
2. The required spacing between insulators must be determined for new conductor. If spacing is more than 7.0 feet apart, then additional insulators should be added to limit cantilever force.
3. Loading on the structural support should be calculated, and if necessary, bracing should be added.

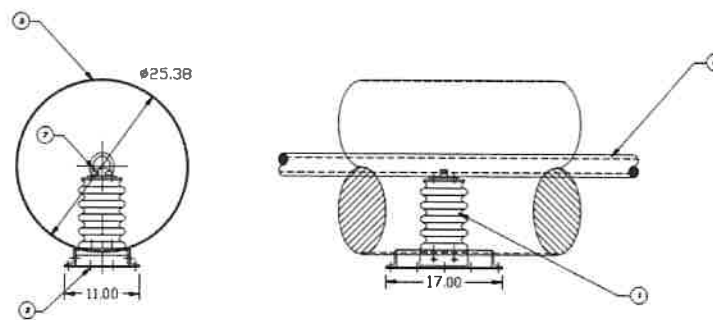


Figure 2: The proposed 2kA IPB detail

The new equipment shall be designed for forty (40) years of life.

8.0 MATERIAL REQUIREMENTS

The Contractor shall be responsible for all materials and their procurement specification.

Materials used in new IPB segments shall be suitable for environmental qualification as specified under paragraph 11.0.

All materials used in manufacturing shall be new and unused.

9.0 FABRICATION AND ASSEMBLY

Only new (not used) components/materials traceable and certified to meet the design requirements shall be utilized in production.

Fabrication shall not begin until all deviations from this specification are resolved, design is approved by NEK, and Contractor receives written approval from NEK.

10.0 INSPECTION AND TEST

The Contractor shall be responsible for conducting all inspection and tests including recording of results and maintaining records thereof.

All testing, inspection, and acceptance criteria shall conform to the applicable codes and standards as specified under section 3.0. When no code or standard applies, the acceptance criteria shall be the Contractor's standard and have proven suitability for the service. The Contractor shall submit a list and brief description of all tests, codes, and acceptance criteria as part of the Proposal. All testing and inspection procedures shall be submitted to the NEK for review, fulfill and approval. NEK shall also be informed about time schedule of all tests. Contractor shall supply overall inspection plan that will include all activities (design, fabrication, delivery ...).

Acceptance shall be based on testing and inspection of the complete assembly and approval of the documented construction, testing and inspection procedures.

11.0 ITEM QUALIFICATION

11.1 General

IPB is a critical component in high-power electrical system, serving several essential functions. It electrically insulates the high-voltage conductors from the grounded enclosure and support structure and other components. This prevents electrical arcing and short circuits, ensuring safe operation.

Support insulators provide mechanical support for the conductors passing through the IPB. They help secure the conductors in place, preventing movement that could lead to mechanical failure.

Covers on the support insulators seal the IPB, preventing the ingress of moisture, contaminants, and other environmental factors. This is crucial for maintaining the dielectric properties of the IPB and ensuring long-term reliability.

11.2 Environmental Qualification

The environmental service condition of the bushings is considered mild.

- Max ambient temperature +40 °C
- Min ambient temperature -25 °C
- Installation height above sea level not greater than 1000 m
- No adverse radiation levels are present.

The environmental qualification shall include documentation which certifies that the test/analysis parameters envelop the specified condition.

11.3 Seismic Qualification

N/A

12.0 CLEANING

All parts shall be free from dirt, scale, and unwanted grease. The equipment shall be handled throughout production and packaging so that no foreign matter will be introduced into or onto the equipment and hinder its operation.

13.0 CORROSION PROTECTION / COATING

All equipment shall be painted and/or protected against corrosion in accordance with the manufacturer's standard procedures and requirements. The final paint coat color shall be RAL 220 80 15.

14.0 MARKING AND IDENTIFICATION

All components shall be clearly identified and where necessary marked in such a way to eliminate any question or confusion at subsequent assembly or repair.

The Contractor shall establish and maintain a system for the identification of materials, parts and components according to IEC standards.

15.0 PACKAGING, HANDLING AND STORAGE

Packaging or crating shall be such as to ensure the satisfactory transportation, handling and arrival of the equipment at its destination in condition as judged by the NEK to be readily handled and placed immediately in permanent position ready for operation. Shipping containers for the equipment shall indicate the identification numbers of the units contained.

The Contractor shall inform the NEK of any special storage requirements sufficiently in advance of shipping to allow for necessary preparation.

16.0 NONCONFORMING MATERIALS

N/A

17.0 RECORDS

17.1 Record system

A record system shall be established and maintained by the contractor to provide documentary evidence of the quality of items and activities affecting quality. Quality assurance records shall include results of reviews, inspections, test, audits, monitoring of work performance and material analysis. Records shall at minimum identify Contractor's name, order number, inspection and data recorder, data inspection that was performed, type of observation, procedures used, results, acceptability and action taken with deficiencies noted. Record of inspection shall also include identity of drawings and procedures utilized along with the revision level.

All quality verification records, procedures and qualifications shall be identifiable to the item or activity involved. All this record shall be send to NEK as they originate and be also included in final documentation package delivery. It shall be possible to uniquely link equipment with any record related with that equipment.

18.0 OTHER REQUIREMENTS

Any additional requirements and/or exceptions imposed beyond this specification requirements during bidding, negotiating and contracting process shall be identified as change to this specification and brought to the attention of the NEK E&DC Superintendent for resolution concurrence and/or approval.

19.0 RIGHT OF ACCESS

N/A

20.0 QA PROGRAM REQUIREMENTS

A certificate of compliance shall be supplied to NEK by Contractor to certify that provided equipment and services meet the requirements of this Specification and related purchase order. Any deviation from the Specification or repair to the equipment, which has been accepted in writing by the NEK, shall not relieve the Supplier from its responsibility for satisfactory equipment performance in accordance with this Specification.

The contractor shall maintain efficient Quality Assurance (QA) program which comply with the requirements of ISO 9001 or comparable standard and with relevant requirements of QA specification NEK QS 610, rev. 2, Generic Quality Assurance Program Requirements. The relevant requirements are indicated as AUGMENTED QUALITY ITEMS - ISO9001 in Attachment A of the QA specification QS 610. The Contractor's bid shall be accompanied by the QA manual of latest revision, if not previous submitted to NEK.

21.0 SPECIAL HANDLING

The Contractor shall specify special handling requirements, if any are required, and provide NEK with appropriate procedure, which shall explain and emphasize them in detail. The Contractor shall also specify additional requirements necessary to maintain equipment warranties.

22.0 SHELF LIFE

The supplier shall not ship any item that has less than 75% remaining shelf life, or be older than one fiscal year, at time of shipment. If the above requirements are not met, the item will be shipped back to the supplier at the supplier's expense.

23.0 10CRF21 REPORTING (For US supplied equipment only)

N/A

24.0 COMMERCIAL GRADE DEDICATION

N/A

25.0 SUPPLIER DOCUMENTATION REQUIREMENTS

The Contractor shall submit complete technical and quality documentation for the offered equipment. Documentation shall include, but not be limited to, the following:

- a. General arrangement, outline, and installation drawings.
- b. A detailed Manufacturing and Quality Plan (MQP) describing the activities used to control the design and manufacture of the equipment. The MQP shall identify the sequence and schedule of design, material procurement, fabrication, inspections, tests, qualifications, and shipment. The plan shall include Record (R), Witness (W), and Hold (H) points for NEK review and approval. The submitted schedule shall be expressed in weeks from the date of receipt of the Purchase Order.
- c. Production test procedures, acceptance criteria, and identification of the applicable codes, standards, and specifications. Such documentation shall be submitted to NEK for review and approval.
- d. Details of any tests, materials, manufacturing procedures, manufacturing sequences, or construction methods specified herein that differ from the Contractor's standard practices.
- e. Installation, Operation, and Maintenance (IOM) instructions, including torque requirements for all bolted connections.
- f. Certified copies of all test reports generated by the Contractor and required by Section 10.0 of this Specification.
- g. Copies of fabrication quality control records, inspection records, and associated documentation.

Documents listed in items (a) through (d) shall be submitted to NEK with the Proposal. All remaining required documentation shall be compiled prior to Factory Acceptance Testing (FAT) and submitted to NEK with the equipment shipment, unless otherwise specified.

The Contractor shall include in the Proposal a summary of any routine, periodic, preventive, predictive, or special maintenance requirements necessary to ensure satisfactory bushing performance throughout the specified 40-year service life.

Any deviations from, exceptions to, or proposed alternatives to this Specification shall be clearly identified on the Equipment Specification Exceptions Form and submitted with the Proposal for NEK review, comment, and acceptance.

Fabrication, procurement of materials, or production activities affecting the design shall not commence until all deviations and exceptions have been resolved, the design documentation has been reviewed and approved by NEK, and written authorization to proceed has been issued by NEK.

26.0 NEK PROPRIETARY DATA

NEK has a proprietary interest in all of the drawings, designs, specifications, documents information or know-how which may be furnished pursuant contract execution and in any know-how improvement, discovery or invention which may be made, developed or conceived in the performance of work hereunder or which may arise or result therefrom (hereinafter collectively referred to as the "Information"). All such information shall be considered proprietary of the NEK. The right to use of all such Information shall be

transmitted to the contractor only for its personal use and shall be entirely restricted to the performance of the contract and subject to the confidentiality provision.

27.0 NON-CONFORMANCE REPORTS

The Contractor shall document and submit all non-conformance reports (NCRs) related to the equipment, materials, manufacturing processes, testing, or inspections performed under this Purchase Order. Each NCR shall include a description of the non-conformance, its cause, corrective actions taken, disposition, and verification of closure. No unresolved NCRs affecting form, fit, function, performance, safety, or contractual requirements shall remain open at the time of shipment unless specifically accepted by NEK in writing.

28.0 REPAIR RECORDS

The Contractor shall maintain records of all repairs performed on materials, components, assemblies, or equipment supplied under this Purchase Order. Copies of repair records shall be made available to NEK upon request.

29.0 SOURCE INSPECTION / SURVEILLANCE NOTIFICATION

NEK reserves the right to visit the Contractor's and its subcontractors' facilities at any time, subject to a two-week prior notice, to witness routine factory tests and any other tests or inspections deemed necessary to verify the correctness of the wiring and proper operation of the equipment. The Contractor and its subcontractors shall provide access to their facilities and records related to the Purchase Order for the purpose of planning and performing source inspection and surveillance activities.

Any inspections, examinations, tests, or surveillance activities performed by NEK or its designated representatives shall not relieve the Contractor or its subcontractors of their responsibility for ensuring full compliance with the requirements of this Specification and the Purchase Order.

30.0 SHIPPING REQUIREMENTS

Contractor shall provide packaging and shipping methods for protection from effect of temperature extremes, humidity, transit shocks and jarring.

Material and all certifications or accompanying documentation supplied under this order shall be directly shipped from the Contractor to NEK. The Distributor shall not take possession of any material or documentation.

The NEK authorized source inspectors have right to hold shipment if purchase order requirements are not met.

31.0 DELIVERY SCHEDULE

Delivery date will be defined in request for quotation for equipment.

32.0 HOLD POINTS

The Contractor shall not proceed with shipment of the equipment or with any subsequent manufacturing stage identified in the approved Inspection and Test Plan (ITP) until NEK has completed the required source inspection and/or witnessed the applicable factory tests, and has formally released this Hold Point in writing.

33.0 VENDOR TECHNICAL MANUAL AND REGISTERED UPDATES

N/A

34.0 TRAINING

N/A

35.0 ATTACHMENTS

Attachment 1: QA specification NEK QS 610, rev2, Generic Quality Assurance Program Requirements