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SPECIFICATION

Specification for the Supply of Front End Waveguide for CLARA at Daresbury Laboratory

Document Change Record

Version	Date	Section/Sheet	Comment
0.1	4/8/2015		Draft for comments
0.2	1/9/2015		Minor corrections

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NOTE

This specification will be an integral part of any subsequent contract. The tenderer must indicate acceptance of all applicable clauses, but may wish to comment on a clause even if it is fully accepted.

Appendix A of this specification lists the information required from the tenderer and it is **ESSENTIAL** that this accompanies the tender reply.

CONTENTS

1. INTRODUCTION

1.1. STFC

Contracts will be awarded by the UK Shared Business Services Limited (UKSBS), acting for and on behalf of the Science and Technology Facilities Council (STFC). All contractual issues will be managed by SBS with technical issues being the responsibility of the Accelerator Science and Technology Centre (ASTeC) and the Technology Department at Daresbury Laboratory.

1.2. Compact Linear Accelerator for Research and Applications

A next-generation light source test facility is to be constructed at the Daresbury Laboratory which will be known as CLARA (Compact Linear Accelerator for Research and Applications), shown in Figure 1. The aim of the CLARA project is to develop a normal conducting test accelerator capable of generating longitudinally and transversely bright electron bunches and to use these bunches in the experimental production of stable, synchronised, ultra-short photon pulses of coherent light from a single pass FEL (Free Electron Laser) with techniques directly applicable to the future generation of light source facilities.

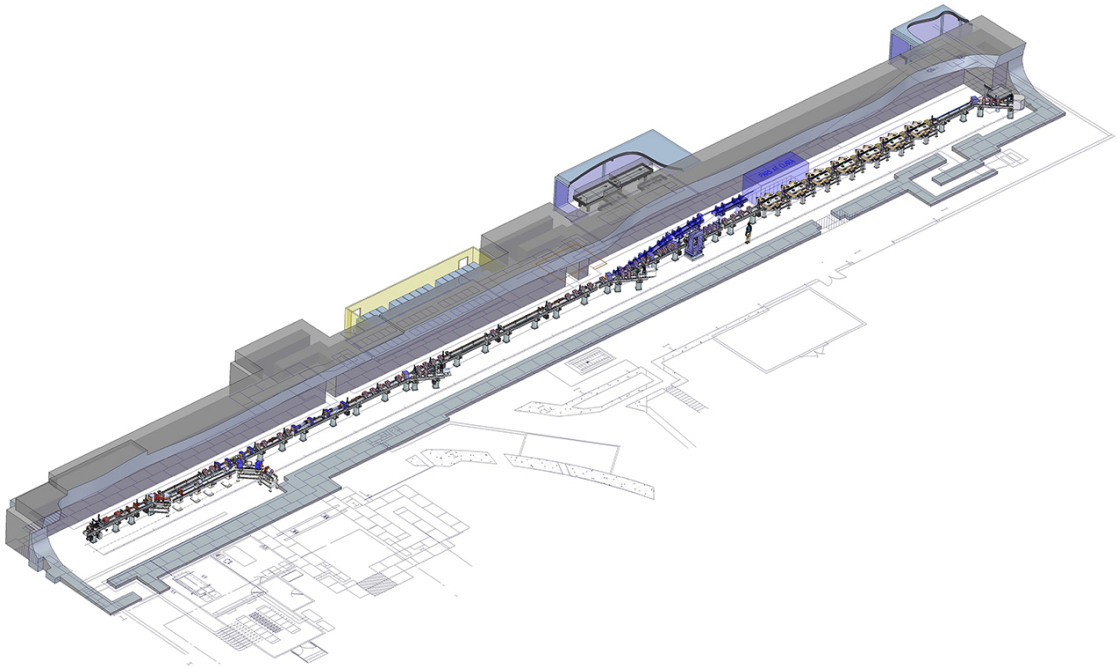

Figure 1: CLARA layout.

Presently at Daresbury Laboratory the Versatile Electron Linear Accelerator (VELA), a 6 MeV machine, is being operated. As part of a complimentary programme of work the CLARA facility is being developed to provide 250 MeV electron beam. The CLARA facility is to be situated in the 'Electron Hall' located at Daresbury Laboratory and a schematic for CLARA is shown in Figure 2.

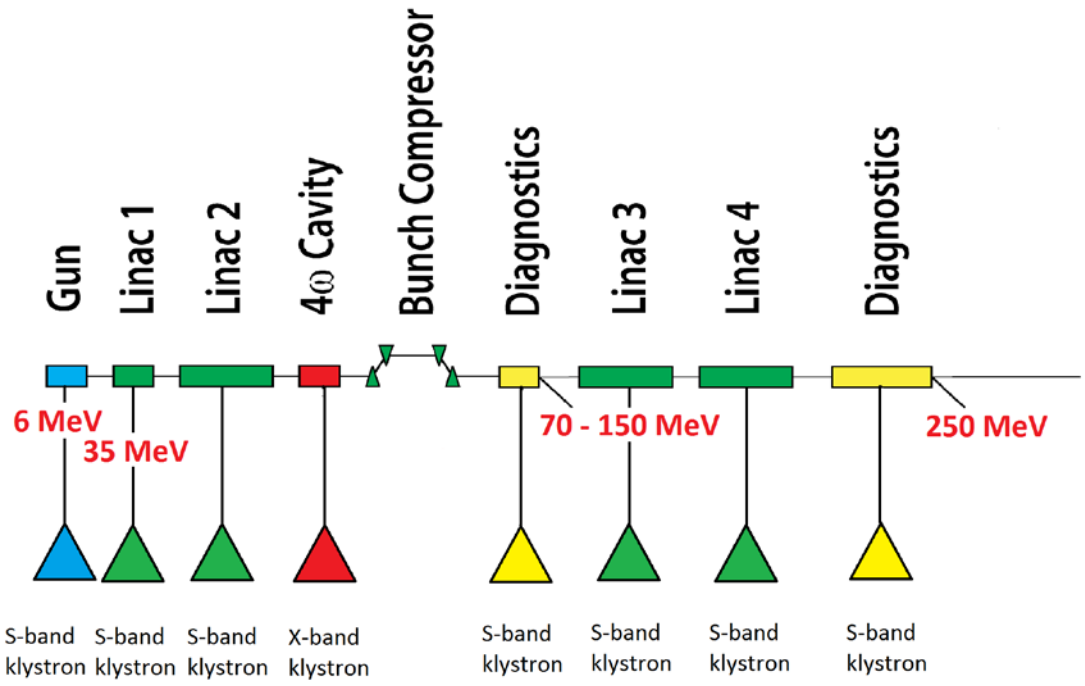

Figure 2: CLARA schematic.

1.3. Operation

The CLARA facility will be operated daily and run for long periods of time. It is planned to operate the electron test accelerator for approximately 4000 hours per year. During operational running of CLARA the linac klystron modulators will often be run at full peak power for long periods, but will also be required to operate at various peak RF power levels with different pulse duration and repetition rates, so as to provide the various operating schemes for the accelerator science to be performed.

1.4. Waveguide Requirements

STFC requires a waveguide system for the CLARA Front End capable of handling RF peak powers of up to 10 MW for the VELA and CLARA RF gun cavities and RF peak powers of up to 45 MW for the first Linac. All of these RF systems will be operated at a frequency of 2998.5 MHz with a pulse width of up to 3 µs and a repetition rate up to 400 Hz. However, it should be noted that these conditions may not all be required at the same time. Detailed waveguide requirements for the RF systems are defined in this document.

1.5. Specification Abstract

This specification concerns assisting in finalising the design, manufacture, and delivery, to Daresbury Laboratory, of the RF waveguide distribution system for the CLARA Front End along with supporting documentation. The waveguide bid must comprise of:-

1. Waveguide with the provision to ensure the waveguide has the ability to be kept temperature stable.

2. RF windows

3. Waveguide splitter
4. Suitable gaskets
5. Delivery to Daresbury Laboratory

2. GENERAL CONDITIONS

2.1 Scope of Contract

2.1.1. The contract will cover the design, manufacture, and delivery of the CLARA Front End waveguide system at STFC Daresbury Laboratory (hereinafter referred to as STFC), Warrington.

2.1.2. The contractor will be required to co-operate closely with STFC and its authorised representative at all stages of the contract. Final design schemes and technical issues will be resolved after adequate discussion.

2.1.3. The provision of RF power to the RF cavities has been determined by STFC and is described within this document.

2.1.4. The manufacturer will be responsible for any departure from anticipated performance due to the failure to adhere to any part of this specification.

2.1.5. No change to the specified requirements is permitted without the written permission of STFC. However, if at any stage of the contract it is clear that advantage could be gained by such modification then the manufacturer is encouraged to bring it to the attention of STFC.

2.2. Sub-Contracts

2.2.1. Full details of all sub-contracts must be available to STFC, and written permission shall be obtained from STFC before placement of such sub-contracts.

2.3. Price and Payment Schedule

2.3.1. The price for major items is to be clearly defined within the bid.

2.3.2. STFC urge tenderers to indicate acceptance of STFC payment terms. However, STFC are prepared to consider alternative payment terms, which should be clearly proposed in the tender documents for possible negotiation in the event of a successful bid.

2.3.3. The payment schedule should also be clearly defined within the bid.

2.4. Timescales and Delivery

2.4.1. Timescales for the project are very important. It is envisaged that the contract will be placed before end of September 2015 and the bidder should provide the best indication of delivery, installation and commissioning based on this date. It should be noted that a preferred delivery date would be the end of December 2015.

2.4.2. A draft manufacturing programme is required with the tender bid and a detailed programme including all necessary acceptance tests shall be issued by the contractor within one week of contract placement and must be approved by STFC. This programme must contain sufficient detail to enable progress of the contract to be monitored accurately.

2.4.3. Written progress reports must be submitted to STFC at intervals of one month during the contract by e-mail addressed to Alan Wheelhouse (Alan.Wheelhouse@stfc.ac.uk).

2.4.4. No change may be made to the agreed programme without the written approval of SBS. SBS must be contacted immediately of any circumstances which might prevent the contract delivery date from being met.

3. RF SYSTEM

3.1. Description of Requirement

3.1.1. Each RF system for the CLARA Front End will consist of klystron modulator and klystron, an RF waveguide section, a normal conducting RF cavity, and a low level RF (LLRF) system.

3.1.2. The maximum peak RF output power is 45 MW at a frequency of 2998.5 MHz.

3.1.3. The RF will be pulsed with a pulse length of up to 3.0 µs, with a repetition rate between 1 Hz and 400 Hz.

3.1.4. Tight amplitude and phase control of the RF power into the cavities is required to ensure that accelerating voltage is maintained at a constant level and is synchronised with the electron beam. The amplitude and phase stability provided by the klystron modulator will be a key component in providing this required control.

3.1.5. During operation the output power to the cavities may be varied. This variation may be done hourly.

3.1.6. During operation the RF pulse width may be varied from 0.25 µs up to at least 3.0 µs. This variation may be done hourly.

3.1.7. During operation the repetition rate may be varied. This variation may be done hourly.

3.1.8. The RF parameters for the Stathclyde gun, high repetition rate gun (HRRG) and Linac 1 are shown below:-

Table 1:- Strathclyde gun RF parameters

Parameter	***Value***	***Notes***
Frequency	2998.5 MHz	
Nominal bandwidth of klystron	5 MHz	At saturation (-1dB points)
Total peak output power	10 MW	Klystron maximum
Average output power	300 W	
Pulse Repetition Rate Range	1 – 10 Hz	
RF Pulse Width	0.25 - 3.0 µs	
Amplitude stability	0.0001	
Phase Stability	0.1°	
Input	WR284 (CERN LIL flange)	

Table 2:- HRRG RF parameters

Parameter	***Value***	***Notes***
Frequency	2998.5 MHz	
Nominal bandwidth of klystron	5 MHz	At saturation (-1dB points)
Total peak output power	10 MW	Klystron maximum
Average output power	10 kW	Klystron maximum
Pulse Repetition Rate Range	1 – 400 Hz	
RF Pulse Width	0.25 - 3.0 µs	
Amplitude stability	0.0001	
Phase Stability	0.1°	
Input	WR284 (CERN LIL flange)	

Table 3:- Specification for Linac 1 RF cavity

Parameter	***Value***
Frequency	2998.5 MHz
Bandwidth	~ 5 MHz
Accelerating Voltage	100 MeV
Accelerating Gradient	25 MV/m
Peak RF input power	up to 45 MW
Pulse Repetition Rate Range	1 – 400 Hz
RF Pulse Width	0.25 - 3.0 µs
Amplitude stability	0.0001
Phase Stability	0.1°
Operational temperature range	30 - 45°C
Input	WR284 (CERN LIL flange)

4. WAVEGUIDE SYSTEM

4.1. Waveguide Layout

The waveguide run layouts for CLARA are shown below and are provided as a .STP file with this documentation:-

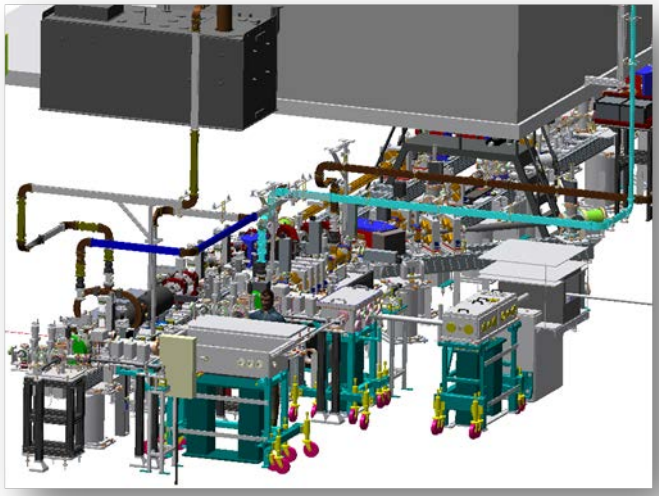

Figure 3: Waveguide run layout for the high repetition rate gun on the VELA line.

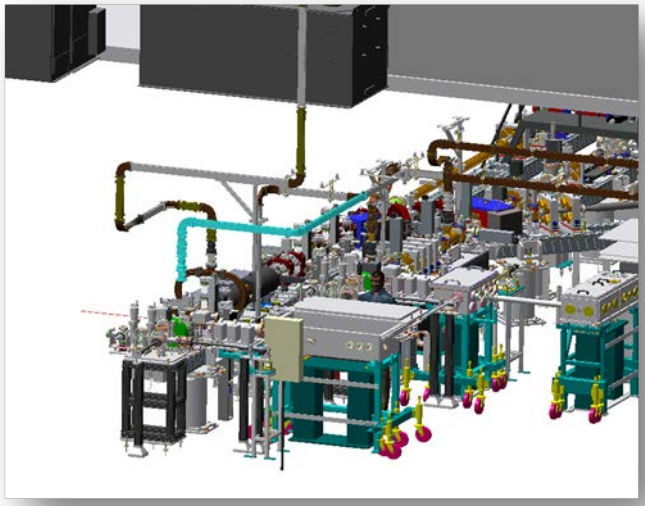

Figure 4: Waveguide run layout for the Strathclyde gun on the CLARA line.

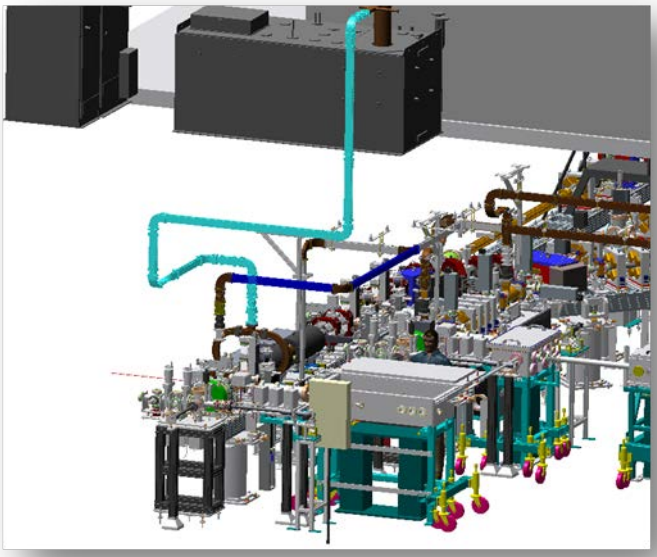

Figure 5: Waveguide run layout for Linac 1 on the CLARA line.

4.1.1. The rf gun cavity position is fixed, however the position of the modulator can be adjusted in discussions with STFC to allow suitable space for waveguide components to be accommodated.

4.1.2. The heights of the waveguide flange on the klystron and the transverse deflecting cavity are still to be fully defined by STFC, though these heights will not vary greatly. The position of the modulator can be adjusted in discussions with STFC to allow suitable space for waveguide components to be accommodated.

4.2. Waveguide Requirements

4.2.1. Phase and amplitude stability is a critical requirement, thus the waveguide system provided should have the ability to be kept temperature stable. A description of how this is to be achieved should be defined within the bid documentation along with any supporting evidence. It should be noted that within the accelerator hall air conditioning will be provided to keep the temperature constant to 23 ± 0.1 °C. However, the outer hall where the modulators are located will have much larger temperature variation as there is limited temperature control in this region, so there will be day to day variations as well as seasonal variations in the temperature.

4.2.2. The waveguide will be pressurised with SF6 up to 1.6 bar between the 2 RF windows.

4.3. Waveguide Requirements

Components required in the waveguide run for the high repetition rate gun on the VELA line, Strathclyde gun on the CLARA line, the Linac 1 line are shown in the tables below.

Table 4:- Waveguide requirements for the high repetition rate gun on the VELA line.

Item No.	Drawing No.	Part Description	Length (mm)	Flange Type	Quantity	Comments
1	256-13218	Straight	467.40	EIA	1	
2	256-12881	E - Elbow	152.40	EIA	1	
3	256-13602	Straight	223.25	EIA	1	
4	256-13225	Straight with SF6 and IR port	152.40	EIA	1	Incorporate SF6 gauge.
5	256-12191	Window	163.00	EIA (Top) LIL (Bottom)	1	10 MW high power RF ceramic window. See Section 4.4
6	256-13603	Splitter	198.65	LIL	1	See Section 4.5
7	256-13462	Pumping port	190.00	LIL	2	

Table 5:- Waveguide requirements for the Strathclyde gun on the CLARA line.

Item No.	Drawing No.	Part Description	Length (mm)	Flange Type	Quantity	Comments
8	256-12878	Straight	1317.30	EIA	1	
9	256-13280	Straight	2035.30	EIA	1	
10	256-13294	Spacer	14.70	EIA	1	
11	256-12881	E - Elbow	152.40	EIA	1	
12	256-13281	Straight	1249.55	EIA	1	
13	256-12879	H - Elbow	152.40	EIA	1	
14	256-13605	Straight	302.46	EIA	1	
15	256-13235	Directional Coupler	157.50	EIA	1	
16	256-13270	Straight with SF6 and IR port	155.00	EIA	1	Incorporate SF6 gauge.
17	256-11870	Straight	112.00	EIA	1	
18	256-12191	Window	163.00	EIA (Top) LIL (Bottom)	1	10 MW high power RF ceramic window. See Section 4.4

Table 6:- Waveguide requirements for the Linac 1 line.

Item No.	Drawing No.	Part Description	Length (mm)	Flange Type	Quantity	Comments
19	256-13225	Straight with SF6 and IR port	152.40	EIA	1	Incorporate SF6 gauge.
20	256-23227	SF6 Pumping Port	152.65	EIA	1	
21	256-12881	E - Elbow	152.40	EIA	1	
22	256-13235	Directional Coupler	157.48	EIA	1	
23	256-13285	Straight	1334.97	EIA	1	
24	256-13267	Straight	874.80	EIA	1	
25	256-12879	H - Elbow	152.40	EIA	1	
26	256-13284	Straight	2111.80	EIA	1	
27	256-12879	H - Elbow	152.40	EIA	1	
28	256-13265	Straight	567.40	EIA	1	
29	256-12881	E - Elbow	152.40	EIA	1	
30	256-13293	Straight	724.37	EIA	1	
31	256-12881	E - Elbow	152.40	EIA	1	
32	256-13262	Straight	294.56	EIA	1	
33	256-12879	H - Elbow	152.40	EIA	1	
34	256-13274	Short Straight	111.50	EIA	1	Contingency Straight
35	256-13235	Directional Coupler	158.25	EIA	1	
36	256-13270	Straight with SF6 and IR port	152.40	EIA	1	Incorporate SF6 pump port
37	TBD	Window	163.00	EIA (Top) LIL (Bottom)	2	45 MW high power RF ceramic window. See Section 4.6
38	256-13261	Vac Pump Port	150.00	LIL	1	

Notes:

- It should be noted that the RF gun cavity position and modulator position are fixed, so the finalised agreed design with STFC should allow suitable flexibility / spacer components to enable the waveguide to be installed.

- Suitable waveguide gaskets are to be supplied with each of the flange connections. In addition please include within the quote an additional 20 EIA gaskets and 10 extra LIL gaskets.

- The IR sensors are to be purchased by STFC. However, provision in the waveguide design should be made to accommodate them, and as such the data sheets for these items have been supplied with the tender documentation.

- Waveguide supports and brackets will be the responsibility of STFC, but it is anticipated that discussions will be held between STFC and the chosen vendor before the final waveguide design is agreed upon.

- If stainless steel flanges are to be included then they should be non-magnetic stainless steel flanges.

4.4. 10 MW RF Window Requirement

Defined below are the requirements for the 10 MW high power RF ceramic window.

Table 7:- 10 MW RF Window Specification

Item	**Parameter**
Waveguide type	WR284
Peak RF Power (MW)	10
RF Pulse Width (µs)	3.0
Maximum Repetition Rate (Hz)	400
Average RF Power (kW)	12
Operating Frequency (MHz)	2998.5 ± 5.0
VSWR for Operating Bandwidth	1.2:1
Insertion Loss (dB)	0.1 dB at 2998.5 MHz
Cooling	Supplier to determine and implement adequate cooling of the window for safe operation at the rated peak and average rated power levels. All relevant details, including connector details are to be provided as part of the bid documentation.
Flanges	EIA (Top), CERN LIL (Bottom)
Operating Pressures	• ≥2 bar at SF6 waveguide side. • < 10 10^{-8} mbar at cavity side.
Vacuum Leak Rate	≤10^{-9} mbar l/s (with Copper gasket)
Cleanliness Requirements	See:- spc-003-Cleaning of Vacuum Items.pdf (Attached)
Baking Requirements	150ºC for 24 hours
Warranty	>12 months

4.5. RF Splitter Requirement

Defined below are the requirements for the RF splitter.

Table 8:- RF Splitter Specification

Item	**Parameter**
Waveguide type	WR284
Peak RF Power (MW)	10
RF Pulse Width (µs)	3.0
Maximum Repetition Rate (Hz)	400
Average RF Power (kW)	12
Operating Frequency (MHz)	2998.5 ± 10.0
Amplitude Balance (± dB)	0.05
Phase Balance (± º)	0.5
Isolation (dB)	>20
Insertion Loss (dB)	0.1 dB at 2998.5 MHz
VSWR, max	1.05:1
Cooling	Supplier to determine and implement adequate cooling of the splitter for safe operation at the rated peak and average rated power levels. All relevant details, including connector details are to be provided as part of the bid documentation.
Flanges	CERN LIL
Operating Pressures	< 10 10^{-8} mbar
Vacuum Leak Rate	≤10^{-9} mbar l/s (with Copper gasket)
Cleanliness Requirements	See:- spc-003-Cleaning of Vacuum Items.pdf (Attached)
Baking Requirements	150ºC for 24 hours
Warranty	>12 months

4.6. 45 MW RF Window Requirement

Defined below are the requirements for the 45 MW high power RF ceramic window.

Table 9:- 45 MW RF Window Specification

Item	**Parameter**
Waveguide type	WR284
Peak RF Power (MW)	45
RF Pulse Width (µs)	3.0
Maximum Repetition Rate (Hz)	400
Average RF Power (kW)	25
Operating Frequency (MHz)	2998.5 ± 5.0
VSWR for Operating Bandwidth	1.2:1
Insertion Loss (dB)	0.1 dB at 2998.5 MHz
Cooling	Supplier to determine and implement adequate cooling of the window for safe operation at the rated peak and average rated power levels. All relevant details, including connector details are to be provided as part of the bid documentation.
Flanges	EIA (Top), CERN LIL (Bottom)
Operating Pressures	• ≥2 bar at SF6 waveguide side. • < 10 10^{-8} mbar at cavity side.
Vacuum Tightness	≤10^{-9} mbar l/s (with Copper gasket)
Cleanliness Requirements	See:- spc-003-Cleaning of Vacuum Items.pdf (Attached)
Baking Requirements	150ºC for 24 hours
Warranty	>12 months

4.7. Tolerances

The tenderer should define how tolerance build-up issues are to be addressed (ie inclusion of flexible sections etc), so as to ensure that the waveguide aligns to the gun and to the klystron flanges on both systems.

4.8. Warranty

4.8.1. The terms of the warranty, which the manufacturer proposes to apply should be stated in the tender. The manufacturer must guarantee the equipment against failure due to either faulty components or manufacture. The minimum expected warranty will be twelve months from the end of commissioning or eighteen months from the delivery of the equipment, whichever is the later. Please confirm in your bid, but note that a longer warranty would be advantageous

4.8.2. Any other warranty statements that apply as part of the tender should be clearly defined within the tender documentation.

Appendix A – Information to be provided with the tender bid

1. The tenderer may submit a number of options within their bid. Each option should clearly define what is included within their bid, and if necessary should state what is not included within the bid for clarity. Any caveats should be clearly defined within the tender documents.

2. The tenderer should provide price and delivery and within their bid provide a breakdown of all major items.

3. The tenderer must consider each clause of the specification in turn, and must clearly indicate whether they comply or do not comply with that clause. It is also recommended that where appropriate for clarity that explanation and evidence is provided for clauses that are acceptable.

4. The preferred vendor will have necessary proven relevant experience in the design, and manufacture of waveguide components. The tenderer should provide examples of similar project work previously conducted.

5. The tenderer is invited to comment on any aspect of the design and to identify possible modifications that could lead to either improved quality or reduced cost (without compromising the performance specification).

6. Please confirm in your bid price including delivery to STFC Daresbury Laboratory.

Appendix B – Documents

Additional documents supplied with the specification are:-

- The .STP file showing the waveguide layouts for the Strathclyde gun on CLARA, the HRRG on VELA and Linac 1 on CLARA.
- The data sheet for the IR detectors.
- Cleaning of vacuum items specification:- spc-003-Cleaning of Vacuum Items.pdf