

Request For Proposal
for
Vibration shakers & Interface equipment
for Large Vibration Test Facility

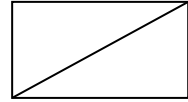


December 2014

Space Environment Test Team
Korea Aerospace Research Institute

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Large Vibration Test Facility



IMPORTANT

1. This RFP should be kept in confidentiality and should neither be copied nor distributed to the third parties.
2. The questions and opinions on this RFP can be asked or suggested to Korea Aerospace Research Institute before submission of the proposal.
3. This RFP should be returned to Korea Aerospace Research Institute with bidder's proposal.
4. This RFP shall be legal bind after the contract is awarded unless the bidder explicitly expresses the differences from the RFP in the compliance sheet.

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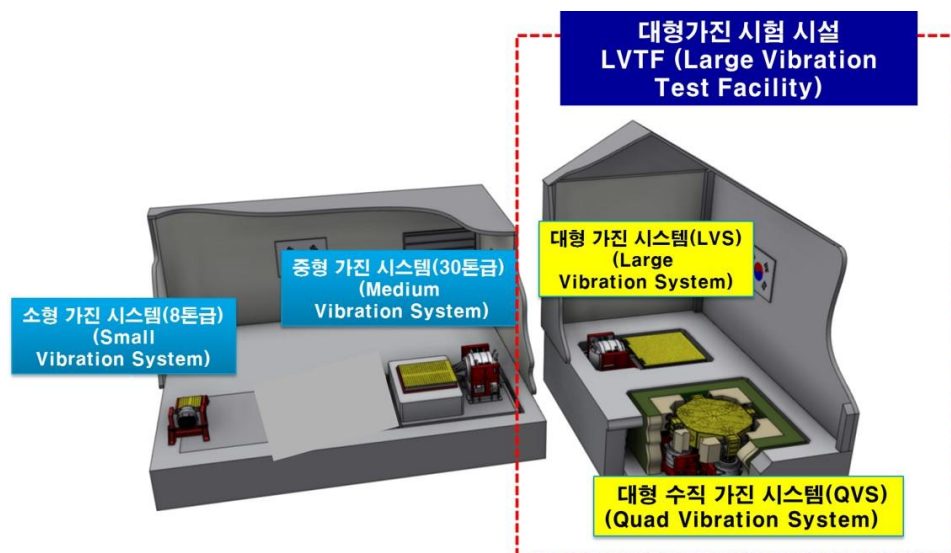
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I. OVERVIEW

1. Overview of the project

- 1.1 Korea Aerospace Research Institute (hereinafter referred to as "KARI") is located at Daeduk Research Complex, 140 km south of Seoul.
- 1.2 KARI has a satellite assembly, integration and test center (hereinafter referred to as "AITC") for joint use by corporations and research institutes for the purpose of the effective development of domestic satellites. And basic facilities and equipment for satellite assembly and test have been supplied, installed and used.
- 1.3 As a Korean government-funded research institute, Korea Aerospace Research Institute (KARI) has undertaken the implementation of the GEO-KOMPSAT-2 (Geostationary Earth Orbit - Korea Multi-Purpose Satellite-2).
- 1.4 To increase the vibration shaker capability and improve the accessibility to satellite for the safe environmental testing, new guided expander system with quad shakers will be designed and built. Also lateral vibration system with 3m x 3m slip table will be designed and built



- 1.5 For these reasons, KARI would like to procure vibration shakers system and related interface equipment.

1.6 The purposes of this project are ;

- 1.6.1 To supply new one shaker for quad vibration system(Multi-shaker operation)
- 1.6.2 To upgrade the performance and extend the useful period for existing three shakers of LDS V984 as those of new one
- 1.6.3 To supply one shaker(Large vibration system) for single operation with 3m x 3m slip table
- 1.6.4 To supply the interface equipment(devices) for shaker

The work covers the procurement and the installation of the shakers, amplifiers, and interface equipment including:

- ✓ Shakers & Interface equipment design
- ✓ Shakers & Interface equipment manufacturing and testing at factory
- ✓ Shakers & Interface equipment Installation and Acceptance Testing
- ✓ Assistance to Installation and Commissioning of the Integrated System

The performance of the individual shakers and of the quad-system shall meet the requirements as detailed in the II Technical requirement.

The performance of interface equipment shall meet the requirements as detailed the II Technical requirement.

- 1.7 The supplier should submit the proposal of the new vibration shaker system in KARI.
- 1.8 All the descriptions in this RFP are minimum requirements and the supplier can suggest a better one to improve the overall performance and cost. But in this case, the proposal should clearly indicate the improvements from KARI's requirements.

2. Requisites of participants

- 2.1 The participants shall supply information about themselves including organization, financial standing, major business, experience in manufacturing and delivery performance for five (5) years and technical support.
- 2.2 The participants shall have experience in manufacturing and delivery of a quad-shakers system for a hydraulic-guidance head expander (above 3 x 3 m) for the purpose of vibration test.

3. Work description

3.1 WP S1000 Shakers, Amplifiers and Interface Management

3.1.1 General

An effective and economical management of the Project shall be conducted. A Project Manager shall be responsible for the management and execution of the work to be performed.

3.1.2 Access

The KARI shall be allowed free access to any plan, procedure, specification or other documentation relevant to the work. Areas and equipment used during the development/testing activities shall also be available for inspection and audit.

The KARI shall be notified at least three weeks before the start of any test program, or as mutually agreed, in order to enable the KARI to select those tests that it wishes to witness. The KARI shall notify its visit at least three week in advance.

3.2 WP S2000 Shakers, Amplifiers and Interface Design

3.2.1 Design

The design of the shakers, amplifiers, interface shall be carried out. Since the four shakers shall be integrated in the seismic foundation to be designed and connected to the table under the Upgrading of the Multishaker Vertical Configuration Contract, a complete mass-spring model of the shaker shall be provided.

3.2.2 Design Review (DR)

Upon successful completion of the Design Review (DR) meeting the KARI shall authorise manufacturing and assembling of the relevant equipment. From that time on, a configuration control system for the documentation and drawings shall be established. All changes to the design shall be processed via Contract Change Notice (CCN) to be approved by KARI.

3.2.3 Deliverables: Design Review Data Package

The following documents shall be handed over to the KARI 2 weeks prior to the DR:

- 3.2.3.1 *Exhaustive list of equipment to be delivered*
- 3.2.3.2 *Technical justification for the selected components*
- 3.2.3.3 *Functional description of the main and auxiliary equipment*
- 3.2.3.4 *Individual shaker performance specifications*
- 3.2.3.5 *Quad Vibration System performance specifications*
- 3.2.3.6 *Detailed internal and external interfaces document*
- 3.2.3.7 *Mass-spring model of one shaker used in quad-shaker*
- 3.2.3.8 *Measurements supporting the equipment performance specifications*
- 3.2.3.9 *Certificates supporting the compliance with EMC requirements*
- 3.2.3.10 *Electrical load list for equipment and auxiliary equipment*
- 3.2.3.11 *Calculation of reactive power and mains filters (if applicable)*
- 3.2.3.12 *Detailed description of the safety devices and interlocks*
- 3.2.3.13 *Design Specifications and FMECA report for the Interlock Supervisory Kit*
- 3.2.3.14 *Cable list with cable number, type, size, length and destination (cable length to be verified at KARI site)*
- 3.2.3.15 *Factory Acceptance Plan*

3.3 WP S3000: Shakers, Amplifiers and interface Manufacturing

During this work package the following tasks shall be performed:

3.3.1 Manufacturing

The system hardware shall be manufactured according to the design accepted under WP S3000.

All manufacturing operations shall be planned in co-ordination with inspections and tests. This planning shall be documented in a concise Manufacturing and Inspection Plan.

3.3.2 Factory acceptance

The Factory Acceptance objective is to verify that the requirements detailed in technical requirements are fulfilled.

The factory acceptance tests and inspections shall be performed according to a Factory Acceptance Plan, which shall identify all the activities to be performed and the requirements intended to be verified.

The Factory Acceptance Review meeting in order to review the results of the implementation of the Factory Acceptance plan shall be organised.

A board composed of members to be agreed with the KARI's representatives shall attend the Factory Acceptance Review meeting and confirm that:

3.3.2.1 *All the equipment to be delivered is ready to be shipped.*

3.3.2.2 *The functional requirements are fulfilled.*

3.3.2.3 *The shakers perform individually as specified*

3.3.2.4 *The Quad vibration system perform as specified*

This task shall be completed upon a successful Factory Acceptance Review.

3.3.3 Deliverables:

3.3.3.1 *Exhaustive list of the equipment to be shipped*

3.3.3.2 *Factory Acceptance test reports*

3.3.3.3 *Factory Acceptance Review minutes of meeting*

3.3.3.4 *KARI on site Acceptance Plan*

3.4 WP S4000 Shakers, Amplifiers and Interface Installation and Testing

During this work package the following tasks shall be performed:

3.4.1 Mechanical installation.

The mechanical installation comprises the:

- Connection of the cooling units to the interfaces with KARI supplies.

3.4.2 Amplifiers:

The amplifiers and cooling units shall be installed in KARI basement Room. The amplifier related equipment shall be brought in the basement room through a loading bay by means of a cargo crane.

3.4.3 Shakers:

The shakers shall be installed in the seismic foundation procured under Part 2.

The shakers shall be transported at the ground floor level and lowered inside the seismic foundation using a 20,000 Kg [10,000kg x 2EA] crane supplied by KARI.

3.4.4 Electrical installation

The electrical installation comprises the:

- 3.4.4.1 *Routing, installation and termination of input and output power cables and control cables.*
- 3.4.4.2 *Connection of power cables (feeder) of the amplifiers to KARI RFI filters.*
- 3.4.4.3 *Continuity and insulation testing according to the Contractor specifications.*
- 3.4.4.4 *Labeling and marking of installed cables and wires.*
- 3.4.4.5 *Connection of earthing cables to the existing KARI dedicated network*

3.5 WP S5000: Shakers, Amplifiers and Interface Acceptance testing

Upon completion of the installation of the shakers and auxiliary equipment, the provisional acceptance of the shakers, not connected to the table, shall take place according to the Acceptance Plan.

The acceptance tests shall be performed in accordance with formal test procedures and documented in test reports.

The draft operation manual will be used during the acceptance test to confirm its suitability to support the operation of the system. KARI staffs and other authorized persons will be trained on the operation of the system during the acceptance test.

The Acceptance Plan shall cover all tests and verifications, which were already performed during Factory Acceptance but are invalidated by the installation at KARI.

During this work package the following tasks shall be performed:

3.5.1 Interlock/ External trip acceptance

- 3.5.1.1 *The proper functioning of the internal and external interlocks shall be verified individually; external trips may be checked by simulation.*
- 3.5.1.2 *The individual shaker amplifiers behavior shall be recorded during a soft and hard shut down and checked against specifications. To this end armature and vibrator body acceleration responses during soft and hard shutdown of a typical sine vibration test run shall be measured.*
- 3.5.1.3 *The Multishaker amplifiers behavior, not connected to the table, shall be recorded during a soft and hard shut down and checked against specifications. To this end each armature and vibrator body acceleration responses during soft and hard shutdown of a typical sine vibration test run shall be measured.*

3.5.2 Vibration acceptance test sequence

The vibration acceptance tests shall verify the capability of the amplifiers to drive the vibrators in compliance with KARI specification. The following vibration tests have to be performed:

- 3.5.2.1 *Individual shaker full performance tests*
- 3.5.2.2 *Quad Multishaker bare armatures, performance tests*
- 3.5.2.3 *Quad Multishaker loaded by interconnecting the four shaker armature with a KARI furnished plate, performance tests*
- 3.5.2.4 *Abort sequence verification*

During the test runs the following measurements shall be recorded:

- 3.5.2.5 *Amplifier AC input voltage and current*
- 3.5.2.6 *Amplifier signal output voltage and current (amplitude and phase)*
- 3.5.2.7 *Matching transformer output voltage and current (if applicable)*
- 3.5.2.8 *Acceleration, amplitude and phase, for each armature*

3.5.3 Cooling units acceptance test

The adequacy of the amplifier forced air-cooling as well as water and oil cooling has to be proven. Therefore temperatures at essential locations shall be measured and recorded while performing a vibration test run at maximum shaker performance (Multishaker configuration) over a period of time, relevant to the test duration.

3.5.4 Acceptance review and acceptance data package

An Acceptance Review (AR) shall be performed to review the results of the implementation of the Acceptance Plan. A Board composed of KARI representatives, including PA Representatives and other member to be agreed shall perform the Acceptance Review.

3.5.5 Deliverable

The AR shall be supported by an Acceptance Data Package (ADP). The ADP shall be provided two weeks prior to the review in 2 paper copies and 5 electronic copies. The ADP shall comprise the following documents:

3.5.6 System Description Document

A system description document containing the Quad Multishaker and Lateral single shaker performance specifications, the general functional description including block diagrams, layouts and principal schematics as necessary.

3.5.6.1 *For each component a document covering:*

- *Product Application: Details the product regarding type and serial number.*
- *Installation and Operation: Concise information on the installation, the adjustment and the operation of the product*
- *Test Instructions: Manufacturer's standard test procedure for the product*
- *Test reports: Results from the manufacturer's standard test procedures for the product.*
- *CE Compliance Certification: Formal certification stating that the equipment provided complies with CE requirements.*
- *Parts List and Drawings: Complete bill of materials listing including assembly drawings associated with the product*

3.5.6.2 *Mechanical Drawings*

- *All mechanical drawings necessary for the installation and maintenance of the equipment, stating dimensions, weights and attachment points*
- *All mechanical interface drawings for cable trays, cable entry and termination*
- *Electrical drawings comprising:*
- *Overall functional block diagram (with reference to the equipment by drawing, or equipment number)*
- *Block or simplified functional diagram of the individual equipment (amplifiers)*
- *Test points and test values*
- *Terminal lists*
- *Cable list comprising cable number, cross section and quality, length and destination*
- *Drawing list of the delivered drawings*

3.5.6.3 *Copies of all Non-conformance Reports and Requests for Waiver*

3.5.6.4 *Manufacturing Inspection Report*

3.5.6.5 *Acceptance test plans, test procedures and test reports*

3.5.6.6 *System Operation Manual*

The system operation manual shall describe the aspects of the operation of the equipment in a logical order, to ensure a safe and proper use. This manual shall contain the following chapters:

- *Pre-operational checks*
- *Start-up and safe shut-down*
- *Operation of equipment and auxiliaries*
- *Inspections*

Note: This document should be written such that it can be used as a stand-alone manual for the facility operator without necessarily consulting the other documents.

3.5.6.7 *Maintenance manual*

The maintenance manual shall describe the aspects of preventive and corrective maintenance. This document shall clearly distinguish between activities that require the special knowledge of the supplier and the activities that can be done by trained KARI personnel.

In addition specific needs for tools or instrumentation shall be included in this section. The shakers' Subcontractor shall identify parts with a limited lifetime.

3.5.6.8 *Amplifier and shaker foot print manual*

The amplifier and shaker footprint manual section shall describe activities, to be performed by trained KARI personnel, to carry out periodic amplifier and shaker signature tests.

3.5.6.9 *Repair manual*

The repair manual section shall assist the maintenance engineer in case a malfunction has to be corrected. It shall advise on the steps to be done to replace or repair, with references to the spare parts list and functional checks required thereafter.

3.5.6.10 *Spare part list*

A recommendation concerning the spare-parts list covering a period of 5 years of operation shall be made and the guarantee that spare-parts can be made available for another 10 years thereafter shall be given.

Delivery time shall be stated for all for spare parts.

3.5.6.11 *Attached documents*

The attached documents which compile information, data sheets, instruction for use, of those deliverable items, which are not covered by the above manual sections (e.g. instruments, auxiliary equipment etc.)

3.5.6.12 *Minutes of the Acceptance Review Board*

3.6 WP S6000 Assistance to Installation and Commissioning of the Integrated System

Support shall be given during the installation of the integrated system and associated auxiliaries and to the System Provisional Acceptance tests of the integrated system, as well as during the guarantee period leading to the System Final Acceptance.

The work package shall include giving support for:

- 3.6.1 Fixing interfaces issues
- 3.6.2 Bolting the shakers inside the seismic foundation
- 3.6.3 Aligning the shakers with respect to the QHE
- 3.6.4 Attending integrated acceptance test campaign
- 3.6.5 Any other related activities necessary to ensure a successful Provisional and Final acceptance of the integrated system.

4. Management reporting Meetings and Deliverables

The hardware deliveries shall include, as a minimum, the following:

Item No.	Part name	Qty	Description
1	One shaker & amplifier system for Quad Vibration System	1	<ul style="list-style-type: none"> - 160 kN Electrodynamic shaker - Including amplifier and related auxiliaries - Including matching transformer - All needed Cables for new installation place
2	Improvement of existing three shakers & amplifiers of LDSV984(Quad Vibration System)	3	<ul style="list-style-type: none"> - 160 kN Electrodynamic shaker - All needed Cables for new installation place - Same lifetime as new ones
3	One shaker & amplifier system for Large Vibration System	1	<ul style="list-style-type: none"> - More than 280kN Electrodynamic shaker - Including amplifier and related auxiliaries - Including matching transformer - All needed Cables for new installation place
4	Shaker Interface equipment	3	<ul style="list-style-type: none"> - 2.0m Head-expander - 1.3 or 1.2m Head-expander - 1.2m Slip table - Related auxiliaries for interface

Kick-off/PDR/CDR/MRR/TRR/FAR reviews shall be held.

Review	Purpose
Kick-off	<ul style="list-style-type: none"> -Review the requirements of the system -Understand and agree the design baselines
Design Review	<ul style="list-style-type: none"> - Verify the compatibility of the design definition and predicted performance with system requirements - Verify the coherency of the equipment specifications with the subsystem specification
Test Readiness Review	<ul style="list-style-type: none"> - Review test plans, sequences and procedures
FAR (Factory Acceptance Review)	<ul style="list-style-type: none"> Review test results (Checking key requirements' performance consistency) - Final acceptance of quad-shakers in Factory
FAR (Final Acceptance Review)	<ul style="list-style-type: none"> -Review test results (Checking key requirements' performance consistency) - Final acceptance of quad-shakers in KARI

5. KARI's undertakings related to the shakers

The following items are provided as KARI's Undertakings:

1. PCU4 and MACU
2. Amplifier modules
3. Access to existing overhead cranes, lifting eyes and lifting slings
4. One office with 1 telephone and 1 PC connected to Internet + access to 1 FAX machine during the installation and commissioning
5. Raw water cooling outlets in the amplifier room
6. Disposal facilities for water and consumables
7. Cable trays located as per system layout drawing
8. Compressed air outlets located close to the vibrators
9. Electrical mains supply at agreed outlets in the plant room and vibrator area
10. Dedicated earth star point located in the plant area close to equipment
11. Four shaker armature interconnecting plate (if required)
12. Qualified operators for instrumentation, operation and data acquisition during acceptance testing
13. On-site access to the existing vibration system data package if required
14. Access to building layout if required
15. Specialized equipment required to complete the agreed acceptance procedure
16. Access to on-site workshop for small mechanical correction work
17. On-site car parking for company vehicle
18. Finished final location to allow the installation of the shakers

6. Warranty

- 6.1 The system shall be warranted for a duration of 1 years from the date of definitive acceptance on the site against any operational faults. The date of acceptance is the date when the whole system is completely installed and its function is approved perfect in a written format by KARI or its representative.
- 6.2 The warranty covers the replacement of faulty parts, the labor required for repair, traveling cost, living fees and all associated necessary costs.
- 6.3 For the upgrading of three shakers used in quad-shakers, contract shall take the responsibility for the normal operation especially in amplifiers system for 5 years. In case of new shakers including amplifiers are supplied, it takes Warranty 6.1.
- 6.4 The contractor or A/S teams shall submit the written plan for repair within 48 hours after the reception of the notification of fault. The contractor or A/S teams shall completely finish the repair within 30 days after the reception of the notification of fault.
- 6.5 For an urgent service during important testing period, the deadline for action is 5 days from the reception of the notification of service. To meet the deadline of the urgent service, KARI will notify the contractor of the test start date and the period 2 weeks before the test start date. The contractor shall stand by the A/S crews at contractor's convenient place during the test period (up to 4 weeks).The contractor shall include a plan for these requirements in the proposal.
- 6.6 To meet these requirements, the contractor shall propose a detailed plan for the prompt repair in the proposal. The detailed information (location, number of crews, resume, phone and FAX numbers, e-mail address, etc.) of the A/S teams shall be shown in the proposal and shall be approved by KARI.

7. Product supply schedule

The contractor shall meet the key points schedule as below;

Items	Key Points Schedule
Quad vibration System (Item #1 & #2)	<ul style="list-style-type: none"> - Arrival at KARI : January 2016 - Installation & Finish site acceptance : February 2016 - Existing three shakers are available to contractor at November 2015
Large Vibration System (Item #3)	<ul style="list-style-type: none"> - Arrival at KARI : January 2017 - Installation & Finish site acceptance : February 2017
Interface equipment (Item #4)	<ul style="list-style-type: none"> - Arrival at KARI : April 2017 - Installation & Finish site acceptance : May 2017

***For the detailed description for item #, refer to hardware deliveries in 4.Management reporting Meetings and Deliverables**

8. Payment Condition

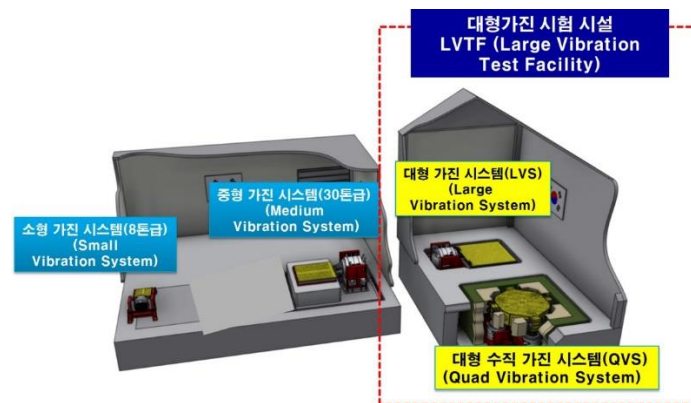
8.1 KARI may terminate this Contract, in whole or in part, ONLY IF GOVERNMENT TERMINATES THE PROGRAM WHICH IS DIRECTLY RELATED TO THIS CONTRACT for its convenience, with sixty (60) days' prior written notice to Contractor.

8.2 KARI's Payment Schedule for this Contract can be adjusted by Government budget profile.

II. Technical Requirements

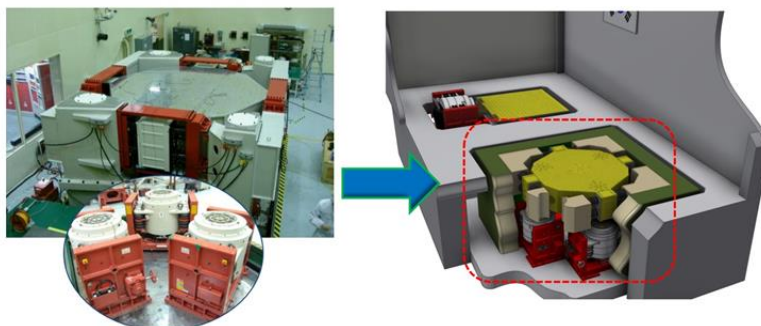
1. Total System Configuration

This document covers the technical requirements applicable to the shakers, associated equipment (power amplifiers, remote control....) and interface (head expander, slip table). The first intention is to purchase standard equipment i.e. new shakers and amplifiers with associated remote control and to modify the existing 3X LDS shakers 984 LS and 3x DPA-K amplifiers of 2004. The system will be used only in quad-shaker configuration. The second intension is to purchase standard equipment of shaker and amplifier over 280kN excitation force. The third intension is to purchase the designed interface for shaker. The requirements listed below only cover the aspects that are important for our application.



2. Technical Requirements for Quad Vibration System

The work scope for quad vibration system is firstly to purchase standard equipment i.e. one shaker and amplifier with associated remote control, secondly to upgrade the existing 3X LDS shakers 984 LS and 3x DPA-K amplifiers to meet the technical requirement for quad-shaker and to have same useful duration as new one. In case of three existing shaker system, it has been more 11 years since it is produced. In this document, quad-shaker means shakers including new shaker and three of existing shakers



2.1 Quad-Shakers Requirements

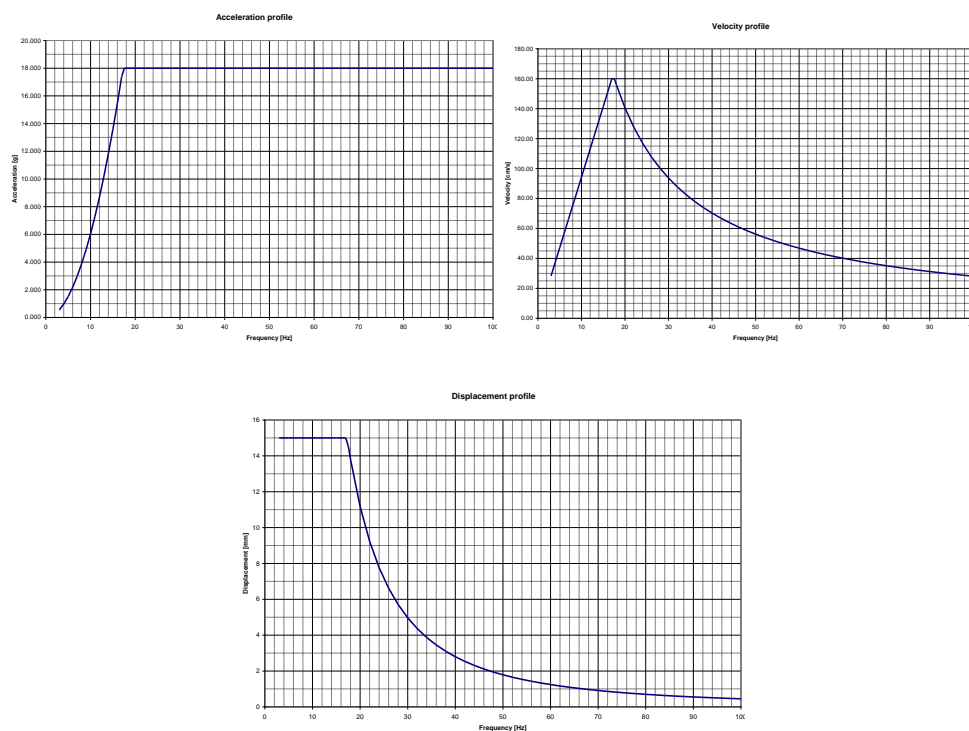
In this proposal, quad shakers consist of new shaker of one and three shakers in KARI. By upgrading work for the three shakers, three shakers shall meet the same requirements described below.

[Q_Sha_1] Shaker performance

The quad-shakers shall have the following minimum performances:

Frequency range	Sine	3-2000 Hz
	Random	10-2000 Hz
	Shock	5-2000 Hz
Nominal maximum Thrust	Sine	≥ 160 kN peak
	Random	≥ 133 kN RMS
	Shock	> 160 kN peak
Nominal maximum no load acceleration	Sine	≥ 100 g
	random	≥ 30 grms
	shock	≥ 100 g
Nominal maximum velocity	sine	≥ 1.6 m/s
Nominal maximum displacement	Sine	≥ 38 mm peak-peak
	Half sine bump	≥ 50.8 mm

Typical maximum sine level test with head expander of 2800 kg + specimen of 300 kg



[Q_Sha_2] Armature Cross-Motion

The cross acceleration measured at the periphery of the armature shall be

< 10% from 5-200 Hz

< 10% from 200-900 Hz except 1 peak at 40%

[Q_Sha_3] Armature acceleration homogeneity

The in-axis acceleration difference between any sensors located on top of the armature shall be:

< 4% from 5-200 Hz

<20% from 200-900 Hz

[Q_Sha_4] Alignment capabilities

Tools shall be provided for fine lateral and vertical adjustment of the shaker position in the seismic block (accuracy better than 0.5 mm)

[Q_Sha_5] Armature vertical positioning

Provision shall be foreseen so that the armatures vertical position of the 4 shakers can be adjusted within ± 1 mm prior to connection to the QHE

[Q_Sha_6] Transport within KARI

Lowering shakers inside the seismic block shall be done using the existing crane (maximum capacity 20 tons)

[Q_Sha_7] Armature and body movement monitoring

It is required to monitor the armature and body movement close to the shaker and close to the remote control. remark: automatic control of the body zero position shall be foreseen.

[Q_Sha_8] Shaker body link

Depending on the selected body configuration, i.e. solid trunions or isolated shakers, disposition for linking the body shall be foreseen.

[Q_Sha_9] Shaker Configuration

Dimension of new shaker shall be same dimension of existing 3-shakers

2.2 Quad-Amplifiers Requirements

[Q_Amp_1] Amplifier performances

The amplifiers shall be designed such that they allow to achieve the shakers performances listed in [Q_Sha-01]

[Q_Amp_2] Signal distortion

For the whole frequency range 5-2000 Hz, the signal distortion measured with a resistive load shall be:

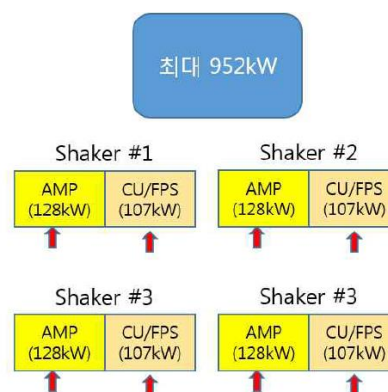
< 0.3 % under full load

< 1% under 10% load condition

Remark: the factory verification can be limited to the frequency range 20-2000 Hz

[Q_Amp_3] Power distribution

The load shall be distributed into four power distribution cabinets. The distribution shall be approved by the KARI during the design review.



[Q_Amp_4] Harmonic distortion

- ❑ The content of harmonic currents in the power supply lines shall not exceed the values as described in the standards IEC 61000-3-9 CD “limit for harmonic current emission”
- ❑ Additional net filtering to meet the above standard shall be part of the delivery and installation as required

[Q_Amp_5] Local control

The amplifier local control shall comprise but not necessarily be limited to the following items:

- Indicators for output voltage and current
- Illuminated push-buttons for amplifier ON/OFF, auxiliary ON/OFF
- key switch for local/ remote control
- Adjustable trip levels for output over current

- Re-settable interlocks for output over voltage and current, supply over current, auxiliary voltages, vibrator over travel, vibrator cooling, field power supply, fuses and external trip signal
- Amplifier gain control
- Emergency stop

[Q_Amp_6] Remote control

The amplifier remote control shall interface with the KARI vibration control console, composed of an LMS SCADAS III front-end piloted from a PC.

The remote control shall be located in the new control room located on the ground floor, and shall have the following functionality:

- Control and monitoring of four vibrators acting as the Multishaker

The remote control shall therefore be equipped

- Switch ON-OFF of amplifiers and auxiliaries in Multishaker mode
- Master gain control and input attenuator for low level testing
- Phase control equipment
- Indicators for output current and voltage
- Additional set of voltage and current measuring converters incl. suitable signal conditioning (for additional measurement interface)
- Transformer tap changing device **if applicable** (contr. Voltage 240 V ac)

The equipment building the remote controls shall be mounted in 19"racks. The front panel design, especially with respect to layout, engraving and labelling shall be approved by the KARI during the design review. The 19"racks shall be on wheel to allow easy displacement.

[Q_Amp_7] Gain control unit (GCU)

The gain control unit shall be able to handle:

The customers vibration signal of 10 volt peak to peak, a frequency range between 3 Hz and 2500 Hz, a signal to noise ratio better than 90 dB.

The unit shall be equipped with:

- An insulating pre-amplifier.
- A low pass filter with a corner frequency of 2500 Hz with a roll-off of 80 dB/decade (optional)
- A front panel mounted selector switch to bypass the filter (optional)
- A step-attenuator with the following attenuator factors (voltage ratio): 1%, 2.5%, 5%, 10%, 20%, 40%, 50%, 60%, 80% and 100% with front panel indicator, selector device.

- A single master gain potentiometer for the Multishaker configuration comprising a front panel mounted single-turn device with a dial in percentage of the output voltage

[Q_Amp_8] Vibrator performance display unit (VPDU)

Output voltage and current measuring converters shall be provided to facilitate additional measuring outputs.

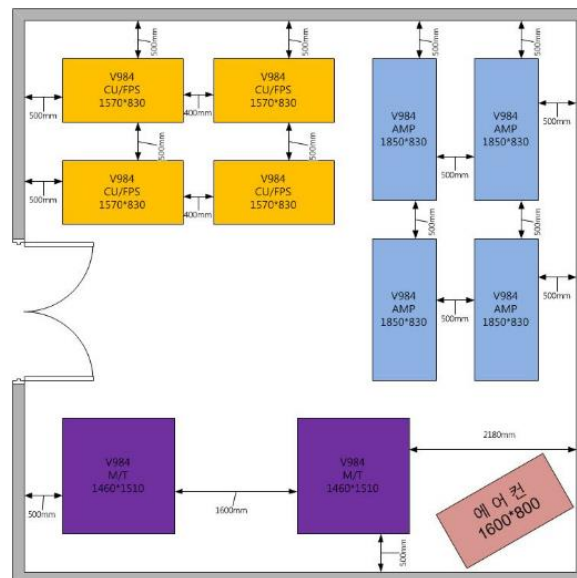
- Vibrators voltage converters with single ended buffered output, providing an output of $50 \text{ mV/V}_{\text{vibr.}}$
- Vibrator current converters with single ended buffered output, provided with the following front panel labelled selectable outputs: $66.66 \text{ mV/A}_{\text{vibr.}}$, $20 \text{ mV/A}_{\text{vibr.}}$, $6.66 \text{ mV/A}_{\text{vibr.}}$ and $2 \text{ mV/A}_{\text{vibr.}}$
- BNC connectors or Cables with BNC connector shall be provided for all the monitoring output

[Q_Amp_9] Amplifier accommodation

The amplifiers shall be installed in the basement close to the seismic block in room.

The allowable floor load for this area is 10 kN/m^2

The room has no gantry crane or other installed lifting equipment



[Q_Amp_10] Lifting and transport

The installation of the amplifiers to the basement will have the following constraint:

- Lowering to the basement with a car-crane through a hatch:

[Q_Amp_11] Mechanical requirements

This describes the general rules to be applied. Some exceptions can be accepted if this would imply a modification to the standard line of the product but does not have an impact on safety issues.

[Q_Amp-11-01] Frames

- The amplifier cabinets shall have free-standing self-supporting frames, which will rest on a flat concrete floor. Shims or adjustable feet shall be incorporated if necessary.
- In case the assembled equipment consists of more than one cabinet, the frames shall be aligned and bolted together firmly after positioning on site.

[Q_Amp-11-02] Enclosures

- The amplifier cabinets shall have metal enclosures which shall meet the protection class IP-20 as described in EN 60529/ IEC529, or better, as well as the requirements specified by the “European Electromagnetic Immunity Standards” as far as applicable for this purpose.
- Removable panel sections and doors shall have suitable (lift-out) hinges for easy removal.
- Door-locks shall be preferably to the 5mm DIN standard.
- Removable panels and doors shall be positioned in such a way that easy access to vital components is guaranteed.
- Hinges should allow for a door opening of 135° minimum.
- All doors in a row should open in the same direction.

[Q_Amp-11-03] Panel internal wiring and termination

- Equipment internal cabling/ wiring shall run in metal or plastic cable conduit with removable covers.
- Flexible hoses to prevent damage shall protect cables and wires attached to front door mounted equipment or swing-out racks.
- Only stranded wire and multi-core cables are allowed.
- Single wire termination shall be with “Crimp-type” wire terminals unless cage-clamp screw-less terminals are applied.
- Soldering of stranded wire is not allowed.
- Terminals and connectors to manufacturers standard.
- A wiring identification system shall be provided for all circuit with non-loosening terminal and wire markers.

[Q_Amp-11-04] External and interface cabling

- Interface cabling between equipment and between equipment and external interfaces shall enter the enclosures from the bottom.

- Cables should either enter the cabinet through properly sized compression type cable glands or clamped to a metal bar for stress relief.
- Cables between interfaces shall run in one length. Joints are not permitted.
- Spare wires of multi-core interface cables shall be put on terminals
- Cable conductors in excess of 16 mm² (A.W.G. 5) may directly be connected to the components concerned if convenient (e.g.. main switches).
- Power cables and cables carrying large currents should be kept separate from control cables.
- Power cables and cables carrying dangerous voltage levels shall be connected to clearly marked terminals and be separated from other terminals by separator plates and labelled covers.

2.3 Quad Vibration System Requirements

[Q_Sys_1] Armature background noise

With grounded amplifier inputs at remote control console input, the maximum allowed acceleration noise level measured on the empty shaker armature centre shall be less than $50 \cdot 10^{-3}$ grms in the frequency band 20-2000 Hz.

[Q_Sys_2] Switch ON-OFF transient

The maximum allowed peak value of a shock impulse, induced by switching ON or OFF the amplifiers shall be less than 0.5 g measured on the empty shaker armature centre

[Q_Sys_3] Total harmonic distortion

The total harmonic distortion measured on an accelerometer response located on the centre of the armature shall be:

- < 10% from 10 –1000 Hz

[Q_Sys_4] Shaker relative response

Equipment shall allow driving simultaneously the 4 shakers with 1 common drive signal [10V peak to peak].

The amplitude difference between the shakers acceleration response (armature centre) shall be

- < 3 % or 20 mg from 10-200 Hz
- < 10 % or 20 mg from 3-1500 Hz

The phase difference between the shakers acceleration response (armature centre) shall be

- < 3° from 10-600 Hz
- < 9° from 5-1500 Hz

[Q_Sys_5] Shaker relative response- protection

Adjustable protection shall be provided in case of amplitude difference between the shakers. This shall trigger a smooth shutdown of the system.

[Q_Sys_6] Smooth shakers shutdown

Any malfunctions of the overall system that requires a test abort shall result in a smooth shutdown of the test run.

A smooth shutdown is:

- **a controlled decrease** of the acceleration down to zero, whereby the acceleration at the payload interface do not exceed the specified acceleration of the on-going test. The decay time shall be

adjustable.

- **simultaneous** on the 4 shakers

At shakers level, the delay measured between the initiation of the shutdown on the 4 shakers shall not result in a phase difference between the armature acceleration in excitation axis larger than 3° or $50 \mu\text{s}$ whichever is the largest.

Note: It is understood that some of the amplifiers internal malfunction might not lead to a simultaneous shutdown of the 4 shakers.

[Q_Sys_7] System auto protection

The shakers and amplifiers shall be equipped with the necessary interlocks to guarantee that their malfunction are detected by the system and that failure propagation is prevented.

[Q_Sys_8] External protection

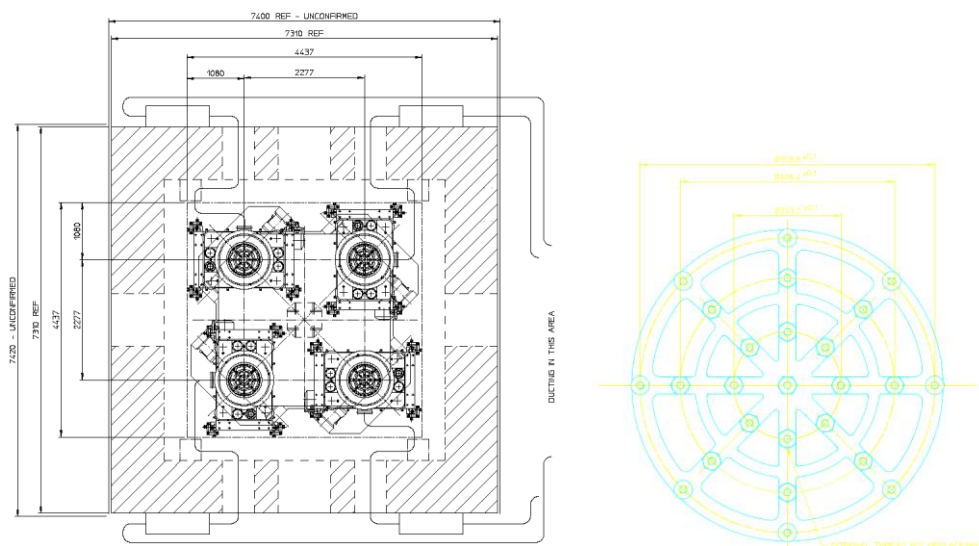
Provision shall be foreseen to connect external safety device (minimum 2) that would also initiate a smooth shutdown of the system.

[Q_Sys_9] Maintenance

For maintenance purposes, it shall be possible to operate 1 shaker individually. This is restricted to 1 shaker at a time. The control may be limited to the local control.

[Q_Sys_10] Configuration

Quad shaker shall be installed as below configuration and shall be performed maintenance without shaker movement.



2.4 Quad Vibration System General Requirements

[Q_Gen_1] Electrical Safety

The amplifiers, shakers, auxiliary equipment, terminal box and cable installation shall be compliant with the Dutch Safety regulation regarding electrical installations “NEN 1010, issue5 (IEC364-485)”

[Q_Gen_2] EMC compliance

With respect to the EMC compliance, the total installation at site has to fulfil the requirements as stipulated in the generic emission standard for industrial environments “EN 61000-6-6:2001” as well as the generic immunity standard “EN 61000-6-3:2001”.

If the actual performance requires such, KARI shall verify the emission standard by measurement and the immunity standard by verification of the design, calculations and manufacturing trajectory.

During the design phase the following aspects shall be addressed:

- Faraday cages and system compartmentalization
- Filter interconnections between compartments
- 3 phase and single phase mains filtering
- Segmented wiring
- Defined earth returns for filter functions
- Choice of components with low equivalent series inductance and resistance
- (ESL/ESR)
- Optical coupling of logic signals
- Screened cables in sensitive areas
- Common mode chokes for symmetrical currents

Note: the same aspect was looked at during the installation of the renewal of the old amplifiers.

[Q_Gen_3] Earthing and screening

Proper earthing screening of the shakers and amplifiers shall be put in place

[Q_Gen_4] Cabling and cabling routing

All electrical cables shall be labelled at both ends. Power cables and signal cables shall be routed separately.

2.5 Quad Vibration System Operation, maintenance and repair requirements

[Q_Main_1] Operators and maintenance personnel training

A comprehensive and effective operation and maintenance training of the KARI personnel shall be performed, preferably during the acceptance test phase at site.

The training shall be limited to those aspects involved with the application of new technology and equipment since a large expertise of the existing and remaining equipment is assumed.

[Q_Main_2] Spare parts

A comprehensive spare-parts list shall be part of the delivery. The list shall include OEM names and part numbers.

Unless justified, parts used shall be commercial off-the-shelf in order to ensure cost effective approach of spare parts procurement.

[Q_Main_3] Diagnostic aids

To facilitate inspections, preventive maintenance and repair, diagnostic aids shall either be incorporated or additionally supplied.

Examples of diagnostic aids shall include:

- Identified test points on electronic circuit boards
- Pre-wired test connectors
- Fault condition signs by LED's (In case of abort, indicating the first event which has triggered the abort)
- Dedicated test modules
- Adaptor cables for use with standard instruments

[Q_Main_4] Alignment and calibration

The design shall be such that alignment and calibration effort shall be kept to a minimum.

All elements requiring alignment shall have good accessibility.

Alignment shall be carried out with standard tools and instruments.

If however special tools/ equipment is required it shall be part of the delivery.

After acceptance at least one year without maintenance is expected.

2.6 Product Assurance requirements

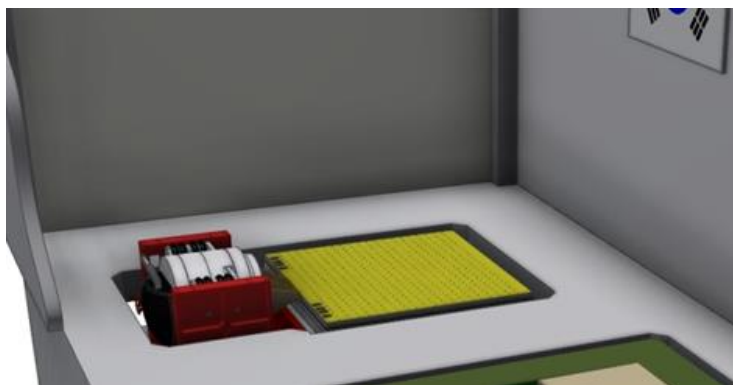
The contractor shall ensure that the equipment is built, installed and commissioned in accordance with the approved design and manufacturing baseline, in a planned and controlled manner.

Any deviation from the specified requirements shall be reported to the KARI in accordance with a procedure to be contractually agreed. The Contractor shall operate a formal non-conformance control system.

3. Technical Requirements for Large Vibration System

3.1 Shaker requirements

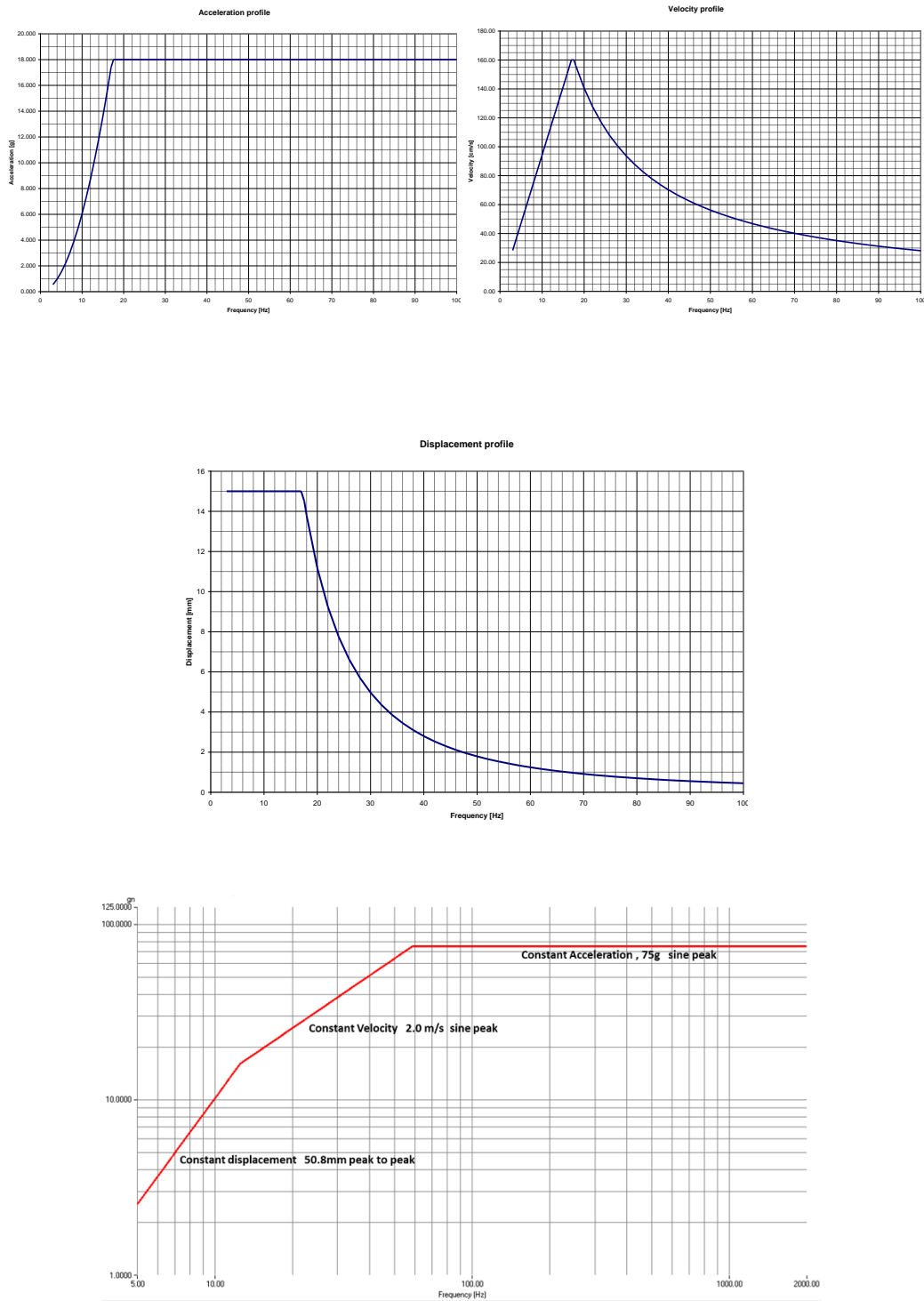
To increase the horizontal shaker capability, 3mx3m slip table system will be designed and built. The work scope for lateral-shaker is to purchase shaker system with associated remote control.



[S_sha-1] Shaker performance

The shaker shall have the following minimum performances:

Frequency range	Sine	3-2000 Hz
	Random	10-2000 Hz
	Shock	5-2000 Hz
Nominal maximum Thrust	Sine	≥280 kN peak
	Random	≥260 kN RMS
	Shock	>800 kN peak
Nominal maximum no load acceleration	Sine	≥75 g
	random	≥60 grms
	shock	≥180 g
Nominal maximum velocity	sine	≥2.0 m/s
Nominal maximum displacement	Sine	≥50.8 mm peak-peak
	Half sine bump	≥63.5 mm
Armature suspension stiffness -Axial(nominal) -Cross axial at insert level -Rotational stiffness		91N/mm 71800M/mm 10700kNm/rad
Armature resonance frequency		>1300Hz
Mechanical resonance of vibrator body		less than 2.5Hz



[S_sha-2] Armature Cross-Motion

The cross acceleration measured at the periphery of the armature shall be

< 10% from 5-200 Hz

< 10% from 200-900 Hz except 1 peak at 40%

[S_sha-3] Armature acceleration homogeneity

The in-axis acceleration difference between any sensors located on top of the armature shall be:

< 4% from 5-200 Hz

<25% from 200-900 Hz

[S_sha-4] Alignment capabilities

Tools shall be provided for fine lateral and vertical adjustment of the shaker position in the seismic block (accuracy better than 0.5 mm)

[S_sha-5] Armature vertical positioning

Provision shall be foreseen so that the armatures vertical position of the shaker can be adjusted within ± 1 mm

[S_sha-6] Transport within KARI

Lowering shakers inside the seismic block shall be done using the existing crane (maximum capacity 20 tons)

[S_sha-7] Armature and body movement monitoring

It is required to monitor the armature and body movement close to the shaker and close to the remote control. remark: automatic control of the body zero position shall be foreseen.

[S_sha-8] Shaker body link

Depending on the selected body configuration, i.e. solid trunions or isolated shakers, disposition for linking the body shall be foreseen.

3.2 Amplifier Requirements

[S_Amp-1] Amplifier performances

The amplifiers shall be designed such that they allow to achieve the shakers performances listed in [S_Sha-01]

[S_Amp-2] Signal distortion

For the whole frequency range 5-2000 Hz, the signal distortion measured with a resistive load shall be:

< 0.5 % under full load

< 2% under 10% load condition

Remark: the factory verification can be limited to the frequency range 20-2000 Hz

Output Voltage	Output Power	20Hz ~ 40Hz (THD)	400Hz ~ 1kHz (THD)	2kHz ~ 3kHz (THD)
100V	100%	0.5%	0.5%	0.8%
50V	25%	0.6%	0.6%	0.8%
10V	1%	2%	2%	2%

[S_Amp-3] Power distribution

The load shall be distributed into four power distribution cabinets. The distribution shall be approved by the KARI during the design review.

[S_Amp-4] Harmonic distortion

- ☐ The content of harmonic currents in the power supply lines shall not exceed the values as described in the standards IEC 61000-3-9 CD “limit for harmonic current emission”
- ☐ Additional net filtering to meet the above standard shall be part of the delivery and installation as required

[S_Amp-5] Local control

The amplifier local control shall comprise but not necessarily be limited to the following items:

- Indicators for output voltage and current
- Illuminated push-buttons for amplifier ON/OFF, auxiliary ON/OFF
- key switch for local/ remote control
- Adjustable trip levels for output over current
- Re-settable interlocks for output over voltage and current, supply over current, auxiliary voltages, vibrator over travel, vibrator cooling, field power supply, fuses and external trip signal

- Amplifier gain control
- Emergency stop

[S_Amp-6] Remote control

The amplifier remote control shall interface with the KARI vibration control console, composed of an LMS SCADAS III front-end piloted from a PC.

The remote control shall be located in the new control room located on the ground floor, and shall have the following functionality:

- Control and monitoring of single vibrator

The remote control shall therefore be equipped

- Switch ON-OFF of amplifiers and auxiliaries in single mode
- Master gain control and input attenuator for low level testing
- Phase control equipment
- Indicators for output current and voltage
- Additional set of voltage and current measuring converters incl. suitable signal conditioning (for additional measurement interface)
- Transformer tap changing device **if applicable** (contr. Voltage 240 V ac)

The equipment building the remote controls shall be mounted in 19" racks. The front panel design, especially with respect to layout, engraving and labelling shall be approved by the KARI during the design review. The 19" racks shall be on wheel to allow easy displacement.

[S_Amp-7] Gain control unit (GCU)

The gain control unit shall be able to handle:

The customers vibration signal of 10 volt peak to peak, a frequency range between 3 Hz and 2500 Hz, a signal to noise ratio better than 90 dB.

The unit shall be equipped with:

- An insulating pre-amplifier.
- A low pass filter with a corner frequency of 2500 Hz with a roll-off of 80 dB/decade (optional)
- A front panel mounted selector switch to bypass the filter (optional)
- A step-attenuator with the following attenuator factors (voltage ratio): 1%, 2.5%, 5%, 10%, 20%, 40%, 50%, 60%, 80% and 100% with front panel indicator, selector device.
- A single master gain potentiometer for the single shaker configuration comprising a front panel mounted single-turn device with a dial in percentage of the output voltage

[S_Amp-8] Vibrator performance display unit (VPDU)

Output voltage and current measuring converters shall be provided to facilitate additional measuring outputs.

- Vibrators voltage converters with single ended buffered output, providing an output of 50 mV/V_{vibr.}
- Vibrator current converters with single ended buffered output, provided with the following front panel labelled selectable outputs: 66.66 mV/A_{vibr.}, 20 mV/A_{vibr.}, 6.66 mV/A_{vibr.} and 2 mV/A_{vibr.}
- BNC connectors or Cables with BNC connector shall be provided for all the monitoring output

[S_Amp-9] Amplifier accommodation

The amplifiers shall be installed in the basement close to the seismic block in room.

The allowable floor load for this area is 10 kN/m²

The room has no gantry crane or other installed lifting equipment

[S_Amp-10] Lifting and transport

The installation of the amplifiers to the basement will have the following constraint:

- Lowering to the basement with a car-crane through a hatch:

[S_Amp-11] Mechanical requirements

This describes the general rules to be applied. Some exceptions can be accepted if this would imply a modification to the standard line of the product but does not have an impact on safety issues.

[S_Amp-11-01] Frames

- The amplifier cabinets shall have free-standing self-supporting frames, which will rest on a flat concrete floor. Shims or adjustable feet shall be incorporated if necessary.
- In case the assembled equipment consists of more than one cabinet, the frames shall be aligned and bolted together firmly after positioning on site.

[S_Amp-11-02] Enclosures

- The amplifier cabinets shall have metal enclosures which shall meet the protection class IP-20 as described in EN 60529/ IEC529, or better, as well as the requirements specified by the “European Electromagnetic Immunity Standards” as far as applicable for this purpose.
- Removable panel sections and doors shall have suitable (lift-out) hinges for easy removal.
- Door-locks shall be preferably to the 5mm DIN standard.

- Removable panels and doors shall be positioned in such a way that easy access to vital components is guaranteed.
- Hinges should allow for a door opening of 135° minimum.
- All doors in a row should open in the same direction.

[S_Amp-11-03] Panel internal wiring and termination

- Equipment internal cabling/ wiring shall run in metal or plastic cable conduit with removable covers.
- Flexible hoses to prevent damage shall protect cables and wires attached to front door mounted equipment or swing-out racks.
- Only stranded wire and multi-core cables are allowed.
- Single wire termination shall be with “Crimp-type” wire terminals unless cage-clamp screw-less terminals are applied.
- Soldering of stranded wire is not allowed.
- Terminals and connectors to manufacturers standard.
- A wiring identification system shall be provided for all circuit with non-loosening terminal and wire markers.

[S_Amp-11-04] External and interface cabling

- Interface cabling between equipment and between equipment and external interfaces shall enter the enclosures from the bottom.
- Cables should either enter the cabinet through properly sized compression type cable glands or clamped to a metal bar for stress relief.
- Cables between interfaces shall run in one length. Joints are not permitted.
- Spare wires of multi-core interface cables shall be put on terminals
- Cable conductors in excess of 16 mm² (A.W.G. 5) may directly be connected to the components concerned if convenient (e.g.. main switches).
- Power cables and cables carrying large currents should be kept separate from control cables.
- Power cables and cables carrying dangerous voltage levels shall be connected to clearly marked terminals and be separated from other terminals by separator plates and labelled covers.

3.3 Large Vibration System Requirements

[S_Sys-1] Armature background noise

With grounded amplifier inputs at remote control console input, the maximum allowed acceleration noise level measured on the empty shaker armature centre shall be less than $50 \cdot 10^{-3}$ grms in the frequency band 20-2000 Hz.

[S_Sys-2] Switch ON-OFF transient

The maximum allowed peak value of a shock impulse, induced by switching ON or OFF the amplifiers shall be less than 0.5 g measured on the empty shaker armature centre

[S_Sys-3] Total harmonic distortion

The total harmonic distortion measured on an accelerometer response located on the centre of the armature shall be:

- < 10% from 10 –1000 Hz

[S_Sys-4] Shaker relative response

Equipment shall allow driving simultaneously the 4 shakers with 1 common drive signal [10V peak to peak].

The amplitude difference between the shakers acceleration response (armature centre) shall be

- < 3 % or 20 mg from 10-200 Hz
- < 10 % or 20 mg from 3-1500 Hz

The phase difference between the shakers acceleration response (armature centre) shall be

- < 3° from 10-600 Hz
- < 9° from 5-1500 Hz

[S_Sys-5] Shaker relative response- protection

Adjustable protection shall be provided in case of amplitude difference between the shakers. This shall trigger a smooth shutdown of the system.

[S_Sys-6] Smooth shakers shutdown

Any malfunctions of the overall system that requires a test abort shall result in a smooth shutdown of the test run.

A smooth shutdown is:

- **a controlled decrease** of the acceleration down to zero, whereby the acceleration at the payload interface do not exceed the specified acceleration of the on-going test. The decay time shall be

adjustable.

Note: It is understood that some of the amplifiers internal malfunction might not lead to a simultaneous shutdown of the shaker.

[S_Sys-7] System auto protection

The shakers and amplifiers shall be equipped with the necessary interlocks to guarantee that their malfunction are detected by the system and that failure propagation is prevented.

[S_Sys-8] External protection

Provision shall be foreseen to connect external safety device (minimum 2) that would also initiate a smooth shutdown of the system.

3.4 Large Vibration System General Requirements

[S_Gen-1] EMC compliance

With respect to the EMC compliance, the total installation at site has to fulfil the requirements as stipulated in the generic emission standard for industrial environments “EN 61000-6-6:2001” as well as the generic immunity standard “EN 61000-6-3:2001”.

If the actual performance requires such, KARI shall verify the emission standard by measurement and the immunity standard by verification of the design, calculations and manufacturing trajectory.

During the design phase the following aspects shall be addressed:

- Faraday cages and system compartmentalization
- Filter interconnections between compartments
- 3 phase and single phase mains filtering
- Segmented wiring
- Defined earth returns for filter functions
- Choice of components with low equivalent series inductance and resistance
- (ESL/ESR)
- Optical coupling of logic signals
- Screened cables in sensitive areas
- Common mode chokes for symmetrical currents

[S_Gen-2] Earthing and screening

Proper earthing screening of the shakers and amplifiers shall be put in place

[S_Gen-3] Cabling and cabling routing

All electrical cables shall be labelled at both ends. Power cables and signal cables shall be routed separately.

3.5 Large Vibration System Operation, maintenance, repair requirements

[S_Main-1] Operators and maintenance personnel training

A comprehensive and effective operation and maintenance training of the KARI personnel shall be performed, preferably during the acceptance test phase at site.

The training shall be limited to those aspects involved with the application of new technology and equipment since a large expertise of the existing and remaining equipment is assumed.

[S_Main-2] Spare parts

A comprehensive spare-parts list shall be part of the delivery. The list shall include OEM names and part numbers.

Unless justified, parts used shall be commercial off-the-shelf in order to ensure cost effective approach of spare parts procurement.

[S_Main-3] Diagnostic aids

To facilitate inspections, preventive maintenance and repair, diagnostic aids shall either be incorporated or additionally supplied.

Examples of diagnostic aids shall include:

- Identified test points on electronic circuit boards
- Pre-wired test connectors
- Fault condition signs by LED's (In case of abort, indicating the first event which has triggered the abort)
- Dedicated test modules
- Adaptor cables for use with standard instruments

[S_Main-4] Alignment and calibration

The design shall be such that alignment and calibration effort shall be kept to a minimum.

All elements requiring alignment shall have good accessibility.

Alignment shall be carried out with standard tools and instruments.

If however special tools/ equipment is required it shall be part of the delivery.

After acceptance at least one year without maintenance is expected.

3.6 Product Assurance requirements

The contractor shall ensure that the equipment is built, installed and commissioned in accordance with the approved design and manufacturing baseline, in a planned and controlled manner.

Any deviation from the specified requirements shall be reported to the KARI in accordance with a procedure to be contractually agreed. The Contractor shall operate a formal non-conformance control system.

4. Technical Requirements for Interface Equipment

4.1 2.0m Head expander requirements

A guided head expander of 2.0m diameter is installed at shaker and allow vertical axis testing where the size or mass of the payload are greater than can be accommodated on the standard shaker armature table.

[I_HE 2.0-1] Head-expander performance

The head-expander shall have the following minimum performances:

Load support capability	6000kg(combined with vibrator load support)
Table size	2000mm Diameter
Useable stroke	2 in D/A
Moment resistant	40kNm
Useable frequency	5Hz ~ 2kHz
First major resonance	> 400Hz
Interface	<ul style="list-style-type: none"> - Single shaker interface - LDS V994 armature table

[I_HE 2.0-2] Mechanical Construction

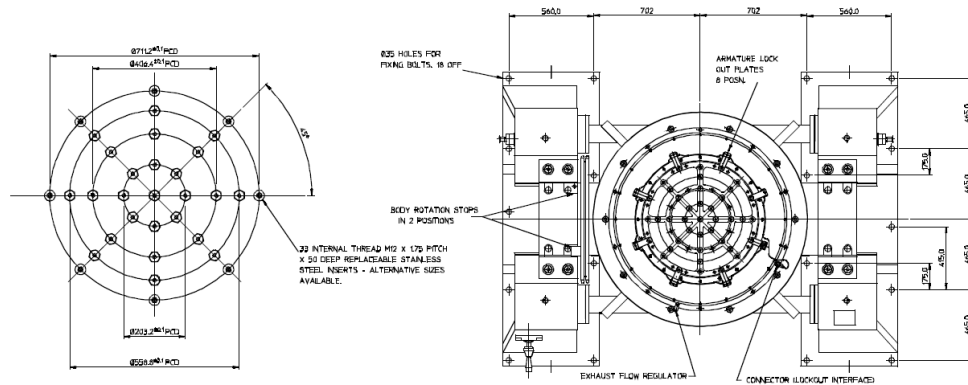
The head-expander shall have the following minimum mechanical construction:

Top face	2000 mm diameter
Flatness tolerance	≤ 0.05 mm/m between top and bottom faces
Material	-Frame: steel -Expander, extender and adaptor plate: magnesium
Finish	Air drying, polyurethane paint on all external surfaces except top and bottom faces.
Weight (expander and guidance system)	Less than 4200kg
Air supply pressure	Less than 7 bar

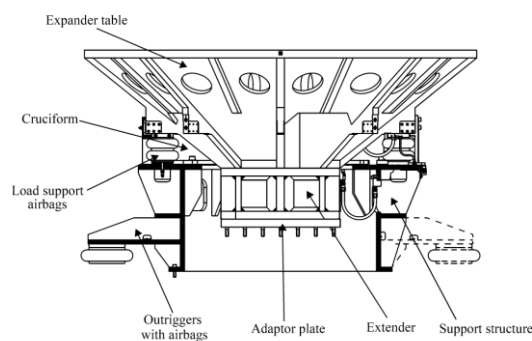
[I_HE 2.0-3] Arrangement of head expander

The complete head expander system shall consists of:

- A fabricated magnesium table and extender bolted together. The table upper surface carries the payload and the extender is connected via an adaptor plate to the single shaker system in this proposal and also V994 armature which has been used in KARI .



- A steel support structure bolted to the shaker top plate, including a steel cruciform in which is mounted a guidance system comprising two hydrostatic journal bearings on a common shaft.
- A load support system comprising eight airbags
- Four outrigger supports with airbag for attachment to the top of the vibrator supports to assist the vibrator Lin-E-Air suspension.
- A free-standing hydraulic power supply with connecting hoses.
- Pneumatic controls and hoses for connecting to the vibrator Lin-E-Air suspension and pneumatic control panel.
- Expander lock-outs protected by interlocks.
- Tuned damper and flat damper installed



[I_HE 2.0-4] Mechanical insert patterns

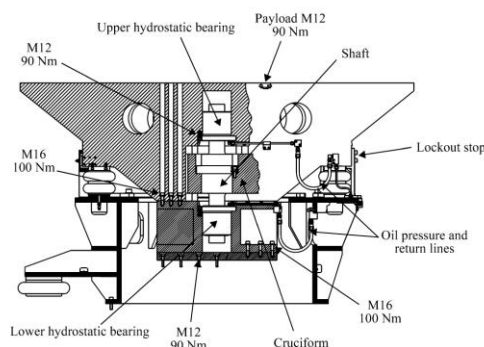
The head expander table shall be fitted with M12 stainless steel inserts in the pattern specified by KARI. Tightening torque is 90 N m

For the adapter plate, to avoid damage to the expander, special steel washers shall be fitted at the bottom of the counter bores. The tightening torque is 100 N m.

[I_HE 2.0-5] Guidance system

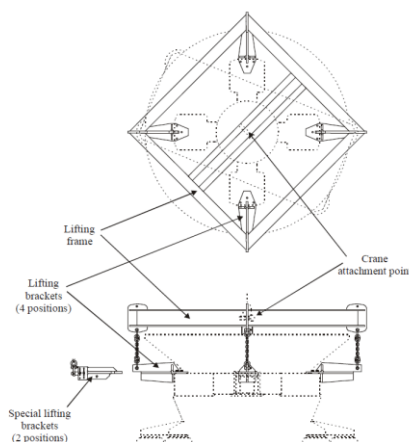
To avoid overloading the shaker guidance system, the head expander shall have its own guidance system.

Two hydrostatic guide bearings shall be located in the central vertical axis of the expander assembly. The bearings shall be pressurized using the free-standing hydrostatic power supply described later in this section.



[I_HE 2.0-6] Lifting device

Lifting device shall be supplied based on following configuration



4.2 1.2m Head expander requirements

A guided head expander of 1.2m ~ 1.3m diameter is installed at shaker and allow vertical axis testing where the size or mass of the payload are greater than can be accommodated on the standard shaker armature table.

[I_HE 1.2-1] Head-expander performance

The head-expander shall have the following minimum performances:

Load support capability	2000kg(combined with vibrator load support)
Table size	1200 ~ 1300mm Diameter
Useable stroke	2 in D/A
Moment resistant	>15 kNm
Useable frequency	5Hz ~ 2.7Hz
First major resonance	> 800Hz
Interface	- Single shaker interface
Moving of head expander system <ul style="list-style-type: none"> - 1200 mm in diameter - 1300 mm in diameter 	<ul style="list-style-type: none"> - Less than 400kg - Less than 440kg

[I_HE 1.2-2] Mechanical Construction

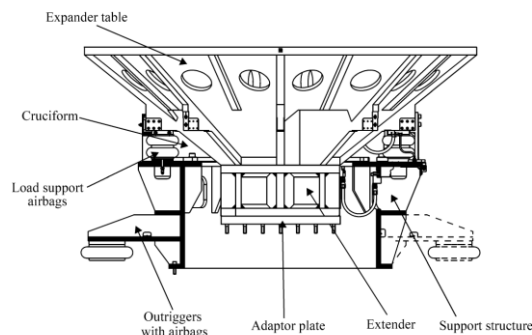
The head-expander shall have the following minimum mechanical construction:

Top face	1200 ~ 1300 mm diameter
Flatness tolerance	≤ 0.05 mm/m between top and bottom faces
Material	-Frame: steel -Expander, extender and adaptor plate: magnesium
Finish	Air drying, polyurethane paint on all external surfaces except top and bottom faces.
Weight (expander and guidance system)	Less than 4200kg
Air supply pressure	Less than 7 bar

[I_HE 1.2-3] Arrangement of head expander

The complete head expander system shall consists of:

- A fabricated magnesium table and extender bolted together. The table upper surface carries the payload and the extender is connected via an adaptor plate to the single shaker system armature which has been used in KARI .
- A steel support frame connected to the vibrator body via extensions to the suspension pillars.
- A steel cruciform mounted on the support frame and in turn supporting
 - o a bearing shaft on which run the expander and extender bearings
 - o four double load support airbags
- Four outrigger supports with airbag for attachment to the top of the vibrator supports to assist the vibrator Lin-E-Air suspension.
- A free-standing hydraulic power supply with connecting hoses.
- Pneumatic controls and hoses for connecting to the vibrator Lin-E-Air suspension and pneumatic control panel.
- Expander lock-outs protected by interlocks.



[I_HE 1.2-4] Mechanical insert patterns

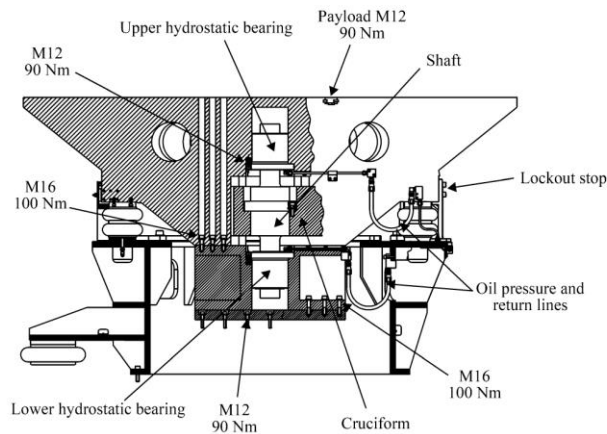
The head expander table shall be fitted with M12 stainless steel inserts in the pattern specified by KARI. Tightening torque is 90 N m

For the adapter plate, to avoid damage to the expander, special steel washers shall be fitted at the bottom of the counter bores. The tightening torque is 100 N m.

[I_HE 1.2-5] Guidance system

To avoid overloading the shaker guidance system, the head expander shall have its own guidance system.

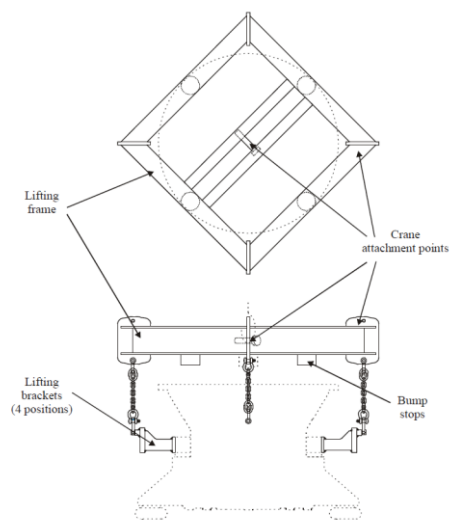
Two hydrostatic guide bearings shall be located in the central vertical axis of the expander assembly. The bearings shall be pressurized using the free-standing hydrostatic power supply described later in this section.



[I_HE 1.2-6] Lifting device

Lifting device shall be supplied based on following configuration.

Complete expander assembly shall be lifted using the special brackets



4.3 1.2m Slip table requirements

A Slip table of 1.2m x 1.2m interface is connected to shaker and allow the lateral axis testing. Slip table is designed to produce vibration from the shaker, supporting the payload and moving in the horizontal axis. Dynamic resistance shall be provided by 9 hydrostatic bearings to prevent excessive cross axial movement reducing the wear and tear on the shaker.

[I_SL 1.2-1] Slip table performance

The slip table shall have the following minimum performances:

Load support capability	2000kg(combined with vibrator load support)
Table size	1200 x 1200mm Diameter
Useable stroke	2 in D/A
Number of hydraulic journal bearings	9 bearings
Useable frequency	5Hz ~ 2,000Hz
First major resonance	> 500Hz
Interface	Single shaker interface
Cross axis performance	-X-axis Better than 15% 5~ 500Hz except for 3 peaks Better than 20% 500~ 1kHz except for 1 peak -Z-axis Better than 15% 5~ 500Hz except for 3 peaks Better than 20% 500~ 1kHz except for 1 peak
Moving of head expander system	Less than 450kg

[I_HE 1.2-2] Mechanical Construction

The slip table shall have the following minimum mechanical construction:

Top face	1200 x 1200 mm (interface area)
Flatness tolerance	≤ 0.03 mm/m
Material	-Frame : steel -Sip table : magnesium alloy type AZ31B with a stiffness of $E=44.1 \times 10^9$ Nm ²
Air supply pressure	Less than 7 bar

[I_HE 1.2-3] Arrangement of slip table

The complete slip table system shall consists of:

- Slip table is designed to produce vibration from the shaker, supporting the payload and moving in the horizontal axis.
- Dynamic resistance shall be provided by 9 hydrostatic bearings to prevent excessive cross axial movement reducing the wear and tear on the shaker.
- The driver is attached to the armature by each of load attachment insert positions in the vertical axis and after rotation of the vibrator to the horizontal axis.
- To prevent oil volatilisation, the slip table plate shall be fitted with an oil moat seal.
- Slip table shall be supplied ad stand alone type

[I_HE 1.2-4] Slip table bearing

■ Free type bearing

- Support load > 65 kN
- Maximum stroke > 75 mm
- Moving (effective) mass < 6 kg
- Operating oil pressure : 170 bar +/-10 bar
- Bearing housing to slip table securing torque : 60 Nm +/- 5Nm
- Bearing support to steel base securing torque : 70 Nm +/- 5Nm
- Hydraulic oil : Shell Tellus 68 or Mobil Delvac 1
- Built-in compliance for thermal expansion
- 6EA

■ Fixed type bearing

- Support load > 65 kN
- Maximum stroke > 75 mm
- Moving (effective) mass < 6 kg
- Operating oil pressure : 170 bar +/-10 bar
- Bearing housing to slip table securing torque : 60 Nm +/- 5Nm
- Bearing support to steel base securing torque : 70 Nm +/- 5Nm
- Hydraulic oil : Shell Tellus 68 or Mobil Delvac 1
- Built-in compliance for thermal expansion
- 3EA

[I_HE 1.2-4] Mechanical insert patterns

The slip table shall be fitted with M12 stainless steel inserts in the pattern specified by KARI.

Tightening torque is 90 N m

III. Format of Proposal

The proposal shall consist of 10 section(S).

- S 1 : Bidder's Qualification Document
- S 2 : Executive Summary (Overview)
- S 3 : Technical Proposal
- S 4 : Warranty Proposal
- S 5 : Maintenance Proposal
- S 6 : Training Proposal
- S 7 : Transport - Handling - Storage Proposal
- S 8 : Work Schedule for Manufacturing, Assembly, Installation, and Interface
- S 9 : Acceptance Test Plan Proposal
- S 10 : Acceptance Data Package (Documentation)
- S 11 : Resume of Key Personnel
- S 12 : Bidder's Confirmation Document for Fully Understanding of the RFP
- S 13 : Price Proposal

The bidder shall present 6 copies of the proposal. A4 or letter size paper shall be used. **The bidder is requested to strictly follow the following illustrated format (tabular form)**. This is very important to compare and evaluate different bidders' proposal. Consequently, disregard for this rule may end up with disqualification. Also, well-prepared and well-organized proposal will be highly appreciated and evaluated. The landscape orientation will be acceptable for tables. The suggested contents in each WP are minimum requirements and works for reminiscences. Ambiguous expression will act adversely to the bidder.

S 1 : Bidder's Qualification Document

(*) Bidder's Qualification : The followings shall be included in WP1.

The participants shall have experience in manufacturing and delivery of a quad-shakers system for a guidance head expander (above 3 x 3 m) for the purpose of vibration test.

The followings shall be included in this Section.

(a) Bidder's last 5 years experience on the prescribed system in this "Request for Proposal" including :

- (1) design
- (2) manufacturing

- (3) installation (specifications, performance, purchaser, supplied year, and price)
- (4) training (operation and maintenance) of the facility

(b) The certification of export license for the items to be delivered.

(c) The installation information (including personnel's information in charge of the facility, address, FAX number, etc.) from the well known institutes or companies which are using the facilities installed by the bidder and/or subcontractor.

(d) The bidder's separate balance sheets of recent 5 years, which is certified by Certified Public Account, including annual turnovers, assets and liabilities (This should be submitted separately for bidder's company only and the total group).

(e) Other information

1. Total Employees

- Total number of Employees (Engineer / Technician)
- Number of Employees for the directly related area

2. Plant Scale

- Total area of space
- Factory & Building area

3. General brochure

4. Any documents with which the bidder can show his/her financial and technical abilities (e.g. technical awards, bank balance, etc.)

(4) training (operation and maintenance) of the facility for foreign countries

(f) ***Bidder's Qualification Evidence Documents*** to show the Part I Section 2 in this RFP. The documents include personnel's information in charge of the facility, address, FAX number and the others from the world well known satellite testing institutes or companies which are using the facilities installed by the bidder

(g) Other information

1. Total Employees

- Total number of Employees (Engineer / Technician)
- Number of Employees for the directly related area

2. Plant Scale

- Total area of space
 - Factory & Building area
3. General brochure
 4. Any documents with which the bidder can show his/her financial and technical abilities (e.g. technical awards, bank balance, etc.)

S 2 : Executive Summary (Overview)

This WP shall include the summary of the all section (3 through 12). The tabular form is recommended.

S 3 : Technical Proposal

This WP (Technical Proposal) shall be written in English. Concise and clear expression is required. A long sentence should be broken down into several sentences. Detailed block diagrams, figures and photos are recommended for clear illustration.

All the descriptions in this RFP is minimum requirements and the bidders can suggest the better one to improve the overall performance and cost. But in this case, the proposal should clearly indicate the improvements on the KARI's requirements with their detail drawings and explicit calculation results.

The contents of proposal will be the measurement of the bidder's technical capabilities. Bidder's proposal will be reviewed by a number of experts at KARI and other institutes.

The bidder shall prepare tables for the check list to show the bidder's compliance with the "Request for Proposal". This table shall be located in front of the Technical Proposal part. The articles in the "Part III Work description" and "Part II Technical Requirements" of the RFP shall be completely enumerated in the table. The table format is as follows:

Check Lists for "Part I Overview work description" and "Part II Technical Requirements"

- | | |
|-----|---|
| ANR | : Article Number in the "Part II & III Technical Requirements" in the RFP. |
| Y/N | : Compliance (Yes or No.) |
| CAP | : Corresponding Article number in the bidder's Proposal to ANR |
| AAM | : Article number of Added Material in the bidder's proposal which is not mentioned in the |

RFP.

	ANR		Y/N	CAP	Remark	AAM	Remark
Part I Or Part II	1)		yes	1)	ditto		
	2)		yes	2)	ditto		
	3)		yes	3)	ditto		
	4)		yes	4)	The specifications look old. We updated them.		
	N/A		N/A	N/A	N/A	5)	We currently developed a new method.
	5)		yes	6)	ditto		
	6)		no	7)	The resolution is high above the necessity. The current technology for the system		
	7)		yes	8)	ditto		
	8)		no	9)	This specification is not compatible with 8) in the proposal. We suggest other approach.		
	9)		yes	10)	ditto		

ditto : The same as stated above or before

Due to the interface issue, the bidders shall deliver a complete design file(AutoCAD or CATIA) or drawings which have the following information :

- Whole set of drawings of slip table system and driver bar with the detail layout of interface-related system
- Slip table base plan
- Distribution network(electricity, oil, cooling water, etc) layout drawings
- Interface details with the test building
- All the calculation notes proving that the total system will be fully compliant with the technical specifications.

S 4 : Warranty Proposal

4.1 Baseline warranty (1 years)

- plan for the prompt repair
- information on A/S team

4.2 Extended warranty (amplifiers of upgrading three shakers)

- **5 years extended warranty for the normal operation under contractor responsibility**
- **or equivalent proposal for lifetime of facilities**

S 5 : Maintenance Proposal

5.1 General description

5.2 Spare parts

5.3 Hardware updating

S 6 : Training Proposal

6.1 The training program

- contents, location, period, etc.

S 7 : Transport-Handling-Storage Proposal

- plan for packaging
- list of special parts and their treatment plan
- storage plan of products for assembly, installation, and interface

S 8 : Work Schedule for Manufacturing, Assembly, Installation, and Interface

The work schedule and installation plan shall be shown as in detail as possible in chronological way. The installation plan shall be detailed enough to figure out daily progress and include the methods and procedures for interface between the equipment and KARI SITC building(electricity, cooling water, etc)

S 9 : Acceptance Test Plan Proposal

9.1 General description

9.2 Acceptance test

9.3. Back-up plan

For the case that the bidder can not meet the requirements or other contractual binds after the

contract is awarded, the bidder shall proposed the back-up plan.

- detailed plan and schedule

S 10 : Acceptance Data Package

10.1. Documentation

- document list (contents, number of page and figure) to be delivered.

S 11 : Resume of Key Personnel

The table shall include the information of the followings :

- (a) Overall project manager
- (b) Mechanical and electrical lead designer
- (c) Other section project leader
- (d) Subcontractor personnel (if any)

S 12 : Bidder's Confirmation Document for Fully Understanding of the RFP

This document shall confirm that the bidder has completely understood the whole RFP, which was written in Korean and English.

S 13 : Price Proposal

Price proposal in Euro

APPENDIX

1. General Terms and Conditions