Requirement for the purchase of

ABEC-7 / 7P Class - High Precision
Angular Contact Ball Bearings
for application in Spacecraft Mechanisms

1. Scope

This document stipulates the requirement of the ABEC-7 / 7P class, high precision angular contact ball bearings of non-separable type for application in spacecraft mechanisms. These bearings are to be used in deep space vacuum of 10^{-10} torr and temperature range of –50ºC to +100ºC at a very low speed, ranging from one revolution per day to one revolution per minute. The bearings have to work with high degree of reliability as well as low torque and torque noise.

2. Bearing Manufacturers and Suppliers Requirements

a. The manufacturer (or) authorized dealer (or) other agencies who wish to quote shall clearly state the details of original manufacturer with country of origin. Authorization letter is must for vendor/supplier other than original manufacturer.

b. The website address of the original manufacturer shall be provided for verification of credentials, product ranges and production capacity.

c. The original manufacturer of the bearings shall have experience of more than 10years in manufacturing of high precision bearings of ABEC-7 class (or) better.

d. Documentary evidence for supply of bearings for various ISRO centre (or) other Govt of India organization (or) international space agencies shall be provided.

e. The party shall submit documentary evidence of at least 10years of operational life for similar bearings in any space mechanisms.

f. Summary of available manufacturing facilities with respect to manufacturing of ABEC-7 / 7P class bearings shall be provided either in the form of document (or) through website.

g. The original manufacturer shall have necessary metrological setup required for inspection. Relevant test certificates as specified shall be provided.

h. The manufacturer shall maintain ISO 9001-2000 certification or equivalent quality management system.

i. On-site inspection of the manufacturing (or) inspection process at specified checkpoints, as mutually agreed and if requested, shall be allowed.

3. TYPE

- Angular Contact; Outer ring relieved; Non-separable; Metallic cage
- ABEC – 7 / 7P standard

4. MATERIALS

Rings, balls : AISI 440C CEVM as per AMS 5618

Surface hardness : > 58 HRC

Race and ball surface finish: 0.05 microns

Cage (ASTM B584-14) : Lead-Bronze with composition either A (or) B

Material-A	Material-B
85% Cu, 5%Sn, 9% Pb, 1% Zn Copper Alloy UNS No: C93500 (Previous designation: B 144-3C); Commercial designation 85-5-9-1	80% Cu, 10%Sn, 10% Pb Copper Alloy UNS No: C93700 (Previous designation: B 144-3A); Commercial designation 80-10-10

5. QUANTITY; DIMENSIONAL AND ENGINEERING DATA

With respect to different bearing sizes the corresponding load rating, ball size and number of balls given in Table-1. This is for the purpose of reference and the manufacturer has to specify their load rating, number of balls and ball size.

Type	Bore Dia mm	Outer Dia mm	Width mm	Load Rating, N			Ball Size mm	No of balls	Qty
				Radial Dynamic	Radial Static	Axial Static			
B	50	90	20	26900	22900	43600	12.7	14	20
E	45	75	16	17200	15100	29000	9.525	16	20
J	15	28	7	2860	1780	3380	3.969	13	30
H2	19.05	25.4	3.97	750	680	790	1.587	30	30

Table 1: Dimensional and Engineering Data

* Static Axial Capacity *is defined as minimum of the axial loads at which :*

a) ball- race contact stress at either inner race or outer race exceeds 4 GPa.

b) elliptical contact formed at ball- race contact truncates.

** Static Radial Capacity *is defined as minimum of the radial loads which results in :*

a) ball- race contact stress at either inner race or outer race exceeding 4 GPa.

b) permanent deformation of 0.0001 times ball diameter in either inner or outer race.

6. CAGE

One piece machined, inner ring land riding.

The required diametral clearance at the ball pockets of the cage with reference to the ball dimension in assembled condition is 450 ± 50 microns. The required clearance at the ring contact area of the cage is 250 ± 50 microns.

7. CONTACT ANGLE

Contact angle should be 15 ± 2 º.

8. RADIAL RUN OUT : The radial run out of the assembled bearing under stipulated axial pre-load given in *Table 2* should be as per ABEC 7 standards

9. TOLERANCES

Ring : ABEC-7P as per ABMA 12.1
(For Inner Diameter till 30mm and for Outer Diameter till 50)
ABEC7 as per ABMA 20 (For other bearings)

Balls : Grade 5 AFBMA standard

10. VISUAL INSPECTION

The inner race, outer race, balls and cage of each bearing are to be inspected under 30× magnification for defects like pits, dents, brinell marks, scratches, burrs, foreign particles, poorly bonded particles or any other significant defects.

A bearing or cage should be rejected for imperfections like:

- Pits, inclusions, raised metal, transverse or axial scratches, etc. in the race way.
- Nicks, dents, cuts, flats, ball dents, brinell marks, scratches etc in contact area.
- Burrs anywhere in inner ring, outer ring or cage.
- Raised metal on mounting surfaces.
- Foreign particles in the ball pockets.
- Poorly bonded particles resulting from improper or incomplete deburring.

11. FUNCTIONAL TEST AND PERFORMANCE REQUIREMENTS

Functional tests are to be conducted to ensure high quality in surface finish of balls and raceways, ball size, sphericity, groove curvatures, cleanliness, etc. Cages are to be tested for its trouble free stable operation.

Low Speed Torque Test

All the bearings are to be torque tested at the stipulated speed and pre-load, in single bearing configuration as given in *table 2*. Torque testing has to be carried out in an adequate low speed torque dynamometer with a small quantity of filtered light oil **(Oil used should be specified in the test report)** applied on bearings. Torque measurements are to be made with high frequency response transducers, which should be extremely sensitive to torque variation (< 2gcm) and shall bring out even small bearing imperfections like surface anomalies, metal damage and geometrical imperfections, which are very critical in the low speed application in deep space.

Bearing Type	Pre-load (Kgf)	Conditions	Torque (gmf-cm)
B	10	Nominal Speed: 2 rpm No of rotations: 3 Temperature : 20 to 25℃	< 150
E	10		< 100
J	1		< 50
H2	1		< 50

Table-2: Bearing Pre-load

Preload shall ensure that a contact stress of 850 to 1000MPa is developed in assembly

12. ASSEMBLY and PACKAGING

The final assembly of the packaging should be done in clean room Cl.10,000 (ISO-class 5) or better. Each assembled bearing shall be individually packed with excess oil (filtered light oil) for storage and protection against corrosion in sealed envelope under high vacuum. Package should be suitable for long term storage.

13. DOCUMENTATION

1. Inspection of Dimensional Data :

   The dimensional and geometrical inspection document should be supplied for all the parts of the bearing to the measurement accuracy given in *Table 3*.

Bore diameter	Nearest to 0.0005 mm
Outer diameter	Nearest to 0.0005 mm
Outer/Inner race width	Nearest to 0.0005 mm
Outer/Inner race land diameter	Nearest to 0.0005 mm
Outer/Inner race roundness	Nearest to 0.0002 mm
Contact Angle	Nearest to 0.5 º
Inner diameter of cage	Nearest to 0.0005 mm
Ball pocket diameter of cage	Nearest to 0.002 mm

Table 3: Inspection and Dimensional Data

2. Preloading graph for all bearings shall be sent along with the inspection reports
3. Low speed torque trace :

   Low speed torque test signature for all the bearings.

4. Certificate:

   Material certificate for all bearing elements viz., races, balls and cage.

   Certificate of conformance of the bearings to ABEC – 7 / 7P Class.

14. COMPLIANCE MATRIX

The following compliance matrix shall be filled compulsorily

No	Description	Requirement	Compliance	Remarks
1	Type of Angular contact Ball bearing	Outer Ring riding, Non separable	Yes/No	
2	Quality Standard	ABEC-7 / 7P		
3	Original Manufacturer details		Name, country	
4	Years of experience	Minimum 10	Yes/No	
5	Previous experience in supplying ABEC-7 quality bearings		Name of the customers	
6	Final Assembly conditions	Clean Room Cl.10,000 (or) better	Mention the clean room class	
7	Material of Rings	CEVM as per AMS 5618	Yes/No	
8	Material of Balls		Yes/No	
9	Hardness	>58 HRC		
10	Surface finish	0.05microns		
11	Cage material	Lead Bronze		
12	Rates offered in slabs as indicated			
13	Contact Angle	15±2°	Yes/No	
14	Visual Inspection	30X		
15	Low speed torque test			
16	Packing			
17	Documentation			

15. Terms of Warranty :

After the receipt of the items at IISU, all relevant documents including the certificate of conformance, material certificates etc will be verified and sample testing will be carried out. The item will be cleared and warranty conditions fulfilled once the documents and sample testing is found satisfactory and conforming to our procurement specifications. This clearance will be effected within 30 days after the date of receipt of the items at IISU.

16. Requirements

Following data shall be provided

- Angular stiffness of bearing (Single / Duplex)
- Radial stiffness of bearing (Single / Duplex)
- Axial stiffness of bearing (Single / Duplex)