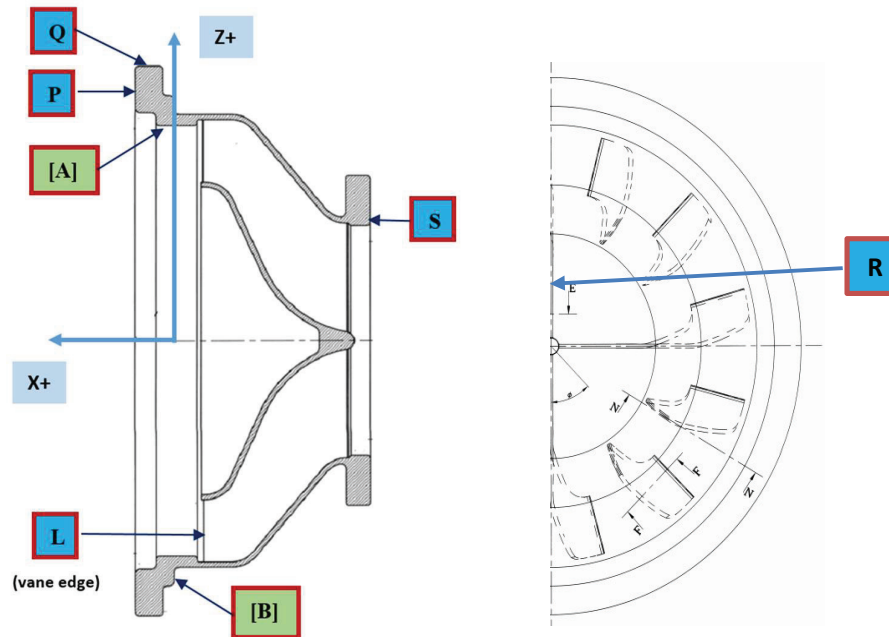


## Details of pre-machining: -

- (a) Hold casting on Right side, level datum [B] & (L) Vane edge; True datum [A] max. Possible extent.
- (b) In above set up turn outer dia  $\text{Ø}318$  [Q] and face [P].
- (c) Additionally, skin-cut may be given on smaller flange face [S].  
(in 2<sup>nd</sup> set-up taking references of features pre-machined in 1<sup>st</sup> set-up.)



**Sketch-1**

**Note A:** During Turning on [Q] OD  $\text{Ø}318$  and facing on left as well as right end faces (ie;  $\text{Ø}318$  face [P] and  $\text{Ø}191$  end face [S]), following 2 conditions must be considered:

- 1) Just minimum cut which is sufficient for removing the high points and establishing a reliable datum in CMM, only need to be provided.
- 2) Based on design requirements and final machining allowances, Maximum limits on the dimension while pre-machining is prescribed as below:

**OD  $\text{Ø} 318$  [Q] may go up to  $\text{Ø}317$ ; 0.5mm facing on [P] face is allowed so that dims.  $(16+6.5=22.5\text{mm})$  is restricted to become 22mm; similarly 0.5mm facing on [S] face to limit dim. 14 to 13.5 only**

Machining must be stopped once any of the above conditions achieved.

**Note B:** After pre-machining, CMM inspection is to be done using pre-machined datum instead of the drg. Datum. Following points to be considered while inspection:

- 1) Additional information [like- concentricity's, perpendicularities, parallelism etc.] between new datum (pre-machined) and the drg. datum is to be reported.
- 2) If some un-cleaned patches after pre-machining are observed (because machining limits are fixed for each castings), details of these patches like depth, length and breadth shall be mentioned in the report in "Visual Remarks" column.
- 3) Whenever any diameter (IDs/ODs) of a casting is to be inspected using CMM, in addition to diameter, other associated data like circularity and off-set/concentricity with respect to axis are to be reported in tabular form, putting additional cells in "Observed Dimensions" column.
- 4) If observed values of typical features (like Ribs, vanes, slots, holes etc.) go out of tolerance provided, Report locations and numbers for deviated features.
- 5) Open tolerance on angle is  $\pm 30'$ , though it is not mentioned in the drawings. It is recommended to amend the Drawings.
- 6) If any depression/ gouge marks observed out of tolerance provided, report locations with respect to datum/reference surface, observed thickness and size of deviations.
- 7) The basic equipment / instruments are only mentioned in the inspection plan but any advanced equipment also can be used at any place.

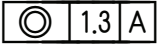
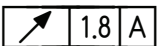
**Details for CMM Datum-1 set-up for pre-machined component (refer sketch-1 above):**

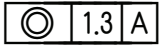
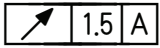
1. Level datum [P] (machined end face.)
2. Align plane [R] (ie; one side plane of the bigger vane) in Y-axis as secondary datum.
3. Set origin (0, 0), at the intersection point between Cylinder [Q] & datum [B].

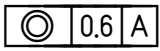

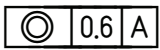
**Details for CMM Datum-2 set-up for Vane inner profile measurement (refer figure-1 in Annexure 1):**

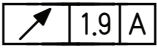
1. Level vane edges (L)
2. Align plane [R] (ie; one side plane of the bigger vane).
3. Set origin (0,0), on inner cup OD ( $\text{\O}184$ )

**Dimensional inspection plan:****DRG. SHEET: 1/1**

<b>PART NAME</b>		<b>LOX TURBINE EXHAUST CASING CASTING</b>		
<b>DRAWING NO.</b>		<b>CE20-1100-91C (R1)</b>		
<b>SL.NO.</b>	<b>DIMENSION SPECIFIED</b>			<b>INSTRUMENTS USED / METHODS</b>
		<b>TOLERANCE</b>	<b>DRG. ZONE</b>	<b>Note : Resolution needed for various instrument / equipments / machines are given as an annexure-A</b>
I	// of "P" (pre machined) w.r.t drg. datum B.	--	--	CMM
II	◎ of "Q" pre machined w.r.t drg. datum A.	--	--	CMM
III	// of "S" w.r.t drg. datum.B	--	--	CMM
<b><u>SECTION-MM</u></b>				
1	R2	± 0.5	G-15	Radius Gauge
2	R2 (outer)	± 0.5	G-14	Radius Gauge
3	R2	± 0.5	G-14	Radius Gauge
4	99.1	± 0.55	G-13	CMM /Height gauge (report min/max)
5	14	± 0.22	G-13	Vernier Gauge (Min / Max)
6	∅284	± 1.3	I-12	CMM (report co- ordinates & circularity also)
7	∅191	± 1.2	I-12	CMM ( measure 2 circles ; report co- ordinates & circularity also)
8			G-12	CMM
9			H-12	CMM
10	86(TH)		J-12	Set value for R18 measurement ( Refer Sl.No.11 )
11	R18	± 0.50	J-13	CMM, radius point method (after set Z=86 & X=99.1; measure at 3 locations & report Min./Max.)
12	∅136	+0.0 -0.2	I-12	CMM ( measure at 100mm from Datum-B)

13	∅133	± 0.8	I-12	CMM (measure 2 circle; report circularity also)
14			K-12	CMM
15	R5	± 0.5	I-12	Radius gauge
16	R2	± 0.5	J-12	Radius Gauge
17	R2	± 0.5	K-12	Radius Gauge
18	R1.5	± 0.5	J-13	Radius Gauge
19	40°	± 30'	K-13	CMM
20	3	± 1	K-13	Thickness mapping on both inner & outer walls of the casting shall be carried out using <b>UT thickness gauge</b> . More no. of points are to be taken on Outer Wall (at least 4 points on each of 12 sectors between vanes).
21	33(TH)		K-14	Set Value for R16 measurement (Refer SL No.23 )
22	112(TH)		J-15	Set Value for R16 measurement (Refer Sl.23 )
23	R16	± 0.5	K-13	CMM (after setting the origin coordinates ;radius point method measure at 3 locations ; report Min/Max)
24	R3 (2 Places)	± 0.5	K-14	Radius Gauge
25			L-14	CMM (report flatness also)
26	104.1	± 0.55	L-13	CMM/Height gauge
27	111.8(TH)		L-13	Set value for R65 measurement (Refer Sl. No.29 )
28	68.8(TH)		I-12	Set value for R65 measurement (Refer Sl. No.29 )
29	R65	± 0.5	I-13	CMM (after setting the origin coordinates ;radius point method measure at 3 locations ; report Min/Max)
30	6.5	± 0.18	L-14	CMM/ Height gauge ( dist from datum[B] )
31	16	± 0.22	K-14	Height Gauge / Vernier Caliper
32	∅318	± 1.8	I-16	CMM / Vernier (Min/Max)

33	Ø264	± 1.3	I-16	CMM (measure 2 circles; report co- ordinates & circularity also)
34	Ø262	± 1.3	I-16	CMM(measure 3 circles; report co- ordinates & circularity also)
35	Ø256	± 0.8	I-15	CMM (measure 1 circle ; report co- ordinates & circularity also)
36			L-15	CMM (of Ø256) (w.r.t M/c OD) (w.r.t 'X' axis )
37	Ø249	± 1.2	I-15	CMM (measure 2 circles; report co- ordinates & circularity also)
38			G-15	CMM
39	Ø184	± 0.7	I-15	CMM (measure 1 circle at lip portion)
40			L-15	CMM (of Ø184) (w.r.t M/c OD) (w.r.t 'X' axis)
41	10.5	± 0.22	K-15	CMM (Min / Max)
42	13.3	± 0.22	K-14	Vernier caliper (calculated value) (Min / Max)
43	15.8	± 0.22	J-14	CMM( of cup face) (Min / Max)
44	74(TH)		J-15	Set Value for R18 measurement (Refer Sl.46 )
45	2(TH)		J-14	Set Value for R18 measurement (Refer Sl.46 )
46	R18	± 0.5	J-14	CMM (after setting the origin co- ordinates ;radius point method measure at 3 locations ; report Min/Max)
47	3	± 1	J-13	Refer Sl. No. 20
48	L			Cut casting dimension; Profile errors of vanes surface using by CMM CAD base inspection. Refer Note-1
49	θ			
50	1	± 0.15	J-14	CMM(dist. b/w cup face & vane edge)
51	65°	± 30'	I-14	CMM (report form error also)
52	R5	± 0.5	I-13	Radius Gauge
53	83.8	± 0.55	I-14	CMM/ Height gauge
54	84	± 0.3	H-13	CMM (distance b/w inner cup edge to bigger vane edge)
55	R2	± 0.5	H-14	Radius Gauge

56	R1	± 0.5	G-14	Radius Gauge
57			G-15	CMM
<b><u>DETAIL-K</u></b>				
58	Ø136	± 0.8	E-14	CMM( refer SL No:12)
59	1	± 0.15	E-14	Instead of these dimension R 25 <sup>±1</sup> has to be measured using template/Radius gauge.
60	2.5	± 0.15	E-14	
61	45°	± 30'	E-14	
<b><u>SECTION-EE</u></b>				
62	2.5	+0.0 -0.3	E-11	Cut casting measurement; (first piece should be cut open and measure using Dial thickness caliper /UT gauge; separately report for 4 bigger vanes & other curved ribs with mapping) <i>For remaining casting accessible portion has to be measured &amp; report separately</i>
<b><u>SECTION-NN</u></b>				
63	30°	± 30'	F-6	CMM ( report Min/Max )
64	Ø136	± 0.8	E-4	CMM (report Min/Max)
<b><u>SECTION-FF</u></b>				
65	33.8°	± 30'	E-2	CMM/ Bevel Protector, only at lip portion to be measure. (report Min/Max)

**Note- 1: - Vane Inner profile inspection (Tolerance= ± 1)**

*Vane qualification: -*

Instead of L, Ø & Φ, inner vane profile variation has to be measured after cutting the casting. One from a batch of 50 castings may be cut and 50% of vanes have to be inspected using CMM with Cad model (refer Datum-2). If anyone among the following conditions such as i) change of vendor ii) change of alloy / material iii) change in processing route – from investment casting to additive manufacturing route or forging route happens, cut casting evaluation should be repeated.

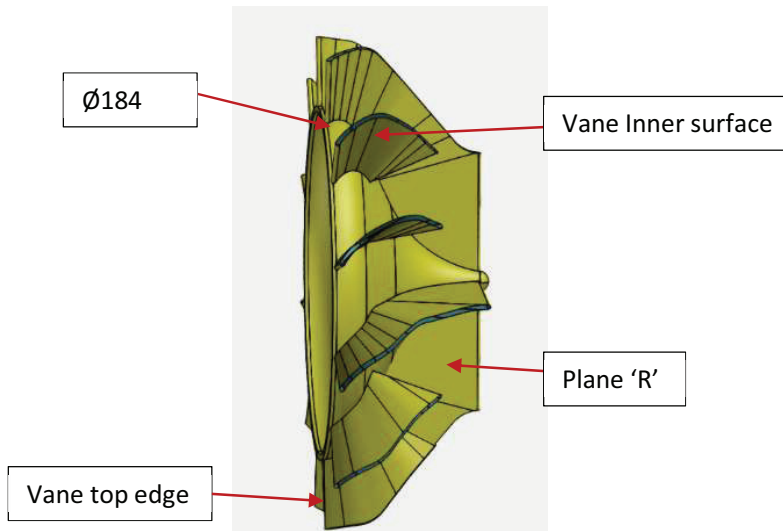
## Annexure-A

- I. **Resolution & Accuracy needed for various Instruments, Equipments and machines used for inspection of the casting products are given below:**

Sl. No.	Instrument/ Equipments	Min. Range	Min. Accuracy	Min. Resolution	Remark
1	3D CMM	500x400x300mm	0.005mm	0.001mm	
2	Micrometer [ID/OD]	0-100mm	0.01mm	0.01mm	
3	Height Gauge	300mm	0.04mm	0.01mm	
4	Profile Projector	250x200mm	0.04mm	0.01mm	
5	UT gauges	0-15mm	0.04mm	0.01mm	
6	Vernier Caliper	0-300mm	0.02mm	0.01mm	
7	Depth Vernier	0-150mm	0.02mm	0.01mm	
8	Thickness Caliper	0-15mm	0.05mm	0.02mm	
9	Radius gauge	0.5-30mm	0.05mm	0.1mm step	
10	Bevel Protector	0-90°	5'	1'	
11	Sine Table	300mm (X & Y)	1'	1'	
12	Rotary Table	300mm (Ø)	1'	30"	
13	Depth Mic.	0-100mm	0.01mm	0.01mm	

**Note:(1) Surface finish for overall area of castings shall be reported against vv or vvv (as applicable) mentioned in the drawings.**

- II. **Figure for Vane Profile measurement: -**



**FIGURE-1 (Cut open casting)**

**Process Critical Dimensions (PCD)**

PCD No.	Drg. No.	Component	Sub System		
2.1	CE20-1100-91C	LOX Turbine Exhaust Casing Casting	CE20 LOX Turbopump Assembly		
Sl. No.	Dimensions		Zone		
	Specification	Measured			
1	$\Phi 256 \pm 0.8$		1		
2	$\Phi 184 \pm 0.7$		2		
3	15.8		3		
4	$3 \pm 1$		4		
5	$3 \pm 1$		5		
6	R18		6		
7	R65		7		
8	$\Phi 136^{-0.2}$		8		
9	Visual inspection				
QC Inspector		RE-QC	Id. No.	Material	QCM

