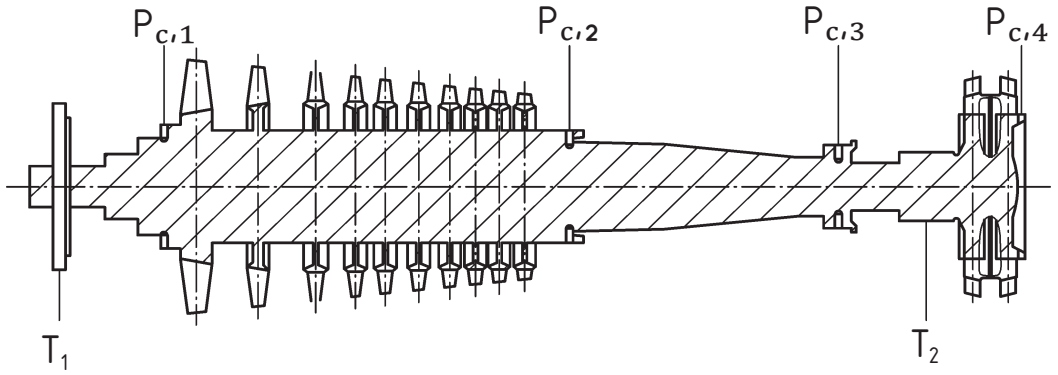
ISO 21940-12 Example calculation of equivalent residual modal unbalances

D.1 Residual unbalance calculation

The principles of residual unbalance calculation are shown in the following example. A recommended procedure is outlined in 9.2.3.

The rotor is a gas turbine rotor with four correction planes $P_{c,1}$ to $P_{c,4}$ (see Figure D.1). The balancing calculations are based on vibration measurements at the two bearings (transducers T_1 and T_2).



Key

$P_{c,1}$, $P_{c,2}$, $P_{c,3}$, $P_{c,4}$ correction planes

T_1, T_2 transducers

Figure D.1 — Example gas turbine rotor

ISO 21940-12 Example calculation of equivalent residual modal unbalances

The service speed of the rotor is 10 125 r/min.

The rotor mass is 1 625 kg.

The permissible total unbalance for an equivalent rigid body according to balance quality grade G 2,5 is taken from ISO 21940-11 to be 2,37 g·mm/kg.

The total residual unbalance for an equivalent rigid body is therefore

$$2{,}37\ \frac{\mathrm{g \cdot mm}}{\mathrm{kg}} \times 1\ 625\ \mathrm{kg} = 3\ 850\ \mathrm{g \cdot mm} \qquad \text{(D.1)}$$

The permissible equivalent first modal unbalance (60 % thereof, see 8.3.4.2) is 2 311 g·mm.

The permissible equivalent second modal unbalance (60 %) is 2 311 g·mm.

ISO 21940-12 Balancing speeds

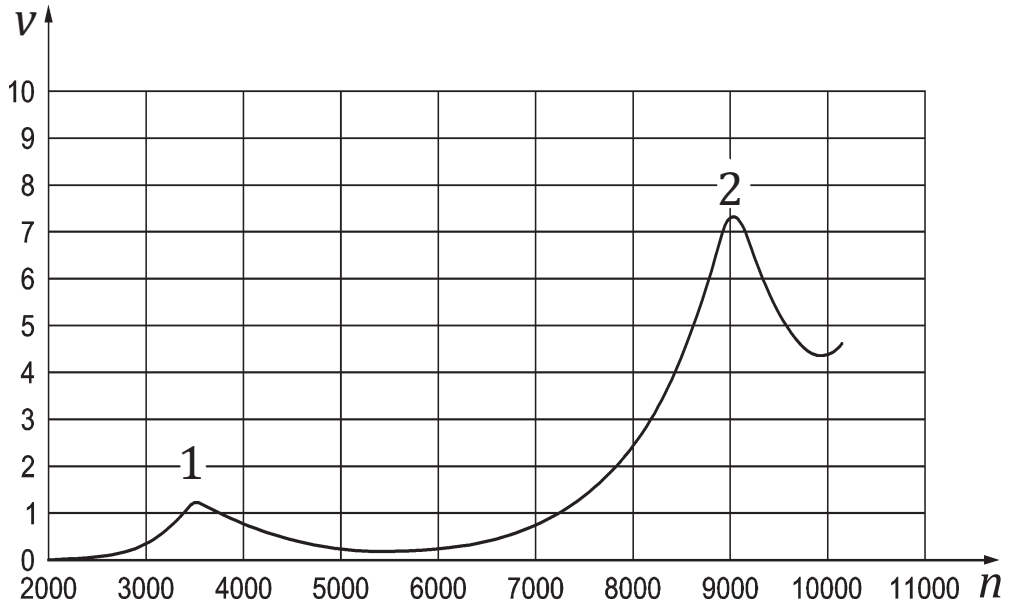
D.2 Influence coefficients

The balancing speeds for this rotor are the following (see Figure D.2):

— 1 000 r/min (low speed);

— 3 400 r/min (just below rotor resonance 1);

— 9 000 r/min (just below rotor resonance 2).



ISO 21940-12 Influence coefficients

Table D.1 — Influence coefficients

Measurement point	Correction plane				Speed
	$P_{c,1}$	$P_{c,2}$	$P_{c,3}$	$P_{c,4}$	r/min
Transducer 1	0,059 4/3° [a]	0,033 0/1°	0,009 12/333° [a]	0,004 90/233°	1 000
Transducer 2	0,002 16/35° [a]	0,022 7/14°	0,033 4/11° [a]	0,042 5/9°	
Transducer 1	0,249/82°	0,343/94°	0,055/222°	0,360/265° [a]	3 400
Transducer 2	0,087/107°	0,157/87°	0,102/34°	0,224/6° [a]	
Transducer 1	1,99/146°	2,29/285° [a]	1,56/293°	2,07/176°	9 000
Transducer 2	1,92/353°	1,99/134° [a]	1,16/109°	0,595/281°	

[a] Influence coefficients used for residual unbalance calculation.

ISO 21940-12 Final vibration readings and residual unbalance

Table D.2 — Final vibration readings

Speed	Transducer		Unit
r/min	T_1	T_2	
1 000	0,01/237°	0,022/147°	mm/s
3 400	0,55/52°	0,22/125°	mm/s
9 000	2,35/305°	1,44/139°	mm/s

Table D.3 — Residual unbalance at 1 000 r/min

Plane	Calculated	Permissible
	g·mm	g·mm
$P_{c,1}$	246	1 925
$P_{c,3}$	671	1 925

Final vibration readings and residual unbalance

Table D.4 — Residual unbalance at 3 400 r/min

Transducer	Calculated	Permissible g·mm
T_1	(0,55/0,36) 1 000 = 1 530 g·mm	2 311
T_2	(0,22/0,224) 1 000 = 982 g·mm	2 311

Table D.5 — Residual unbalance at 9 000 r/min

Transducer	Calculated	Permissible g·mm
T_1	(2,35/2,29) 1 000 = 1 026 g·mm	2 311
T_2	(1,44/1,99) 1 000 = 723 g·mm	2 311