Turbine Overspeed after Load Rejection

Speed rise of a turbine-generator after load rejection from energy admitted while the valves close and from trapped steam, against the shaft inertia.

Method: Rotor energy balance after load rejection

Input parameters

Unit system: SI

Parameter	Value	Unit
Shaft-line moment of inertia	35,000	kg·m²
Rated speed	3,000.0	rpm
Power before the rejection	200.00	MW
Effective valve closing time	0.30000	s
Steam trapped downstream of the valves	400.00	kg
Usable enthalpy drop of trapped steam	300.00	kJ/kg
Expansion efficiency	75.000	%

Calculated results

Parameter	Value	Unit
Energy during valve closure	30.000	MJ
Energy from trapped steam	90.000	MJ
Kinetic energy at rated speed	1,727.2	MJ
Peak speed	3,102.5	rpm
Overspeed	3.4155	%

Notes for this case

• Energy into the rotor: P·t_c/2 while the valves close linearly, plus the trapped steam expanding in the turbine; ½J(ω₂² − ω₁²) equals their sum (losses and windage neglected, so it is conservative). Reheat units have large trapped volumes in reheaters and crossovers, hence intercept valves. Overspeed trips are usually set near 110 %.

Formula and method

$$E = \frac{P t_c}{2} + m_{tr} \Delta h \eta, \quad \omega_{max} = \sqrt{\omega^2 + \frac{2E}{J}}$$

Variables

J	Shaft-line moment of inertia	kg·m²
n	Rated speed	rad/s
P	Power before the rejection	W
t_c	Effective valve closing time	s
m_{tr}	Steam trapped downstream of the valves	kg
Δh	Usable enthalpy drop of trapped steam	J/kg
η	Expansion efficiency	-
E_v	Energy during valve closure	J
E_{tr}	Energy from trapped steam	J
E_0	Kinetic energy at rated speed	J
n_{max}	Peak speed	rad/s
$n_{max}/n - 1$	Overspeed	-

Method and standards

Overspeed.

Assumptions and limits

- No losses or windage; linear valve closure.

References

Rotor energy balance after load rejection

Report details

Report reference	FCC-B6Y1-8166 (the same inputs always give the same reference)
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Release checks	3 reference cases of this calculator, computed independently, are checked on every release

Results are for engineering estimation. Verify critical designs against the referenced standards and your own data.

This calculator online

https://calc.firecad.com/boilers-power-plant/steam-turbines/turbine-overspeed-trapped-steam

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.