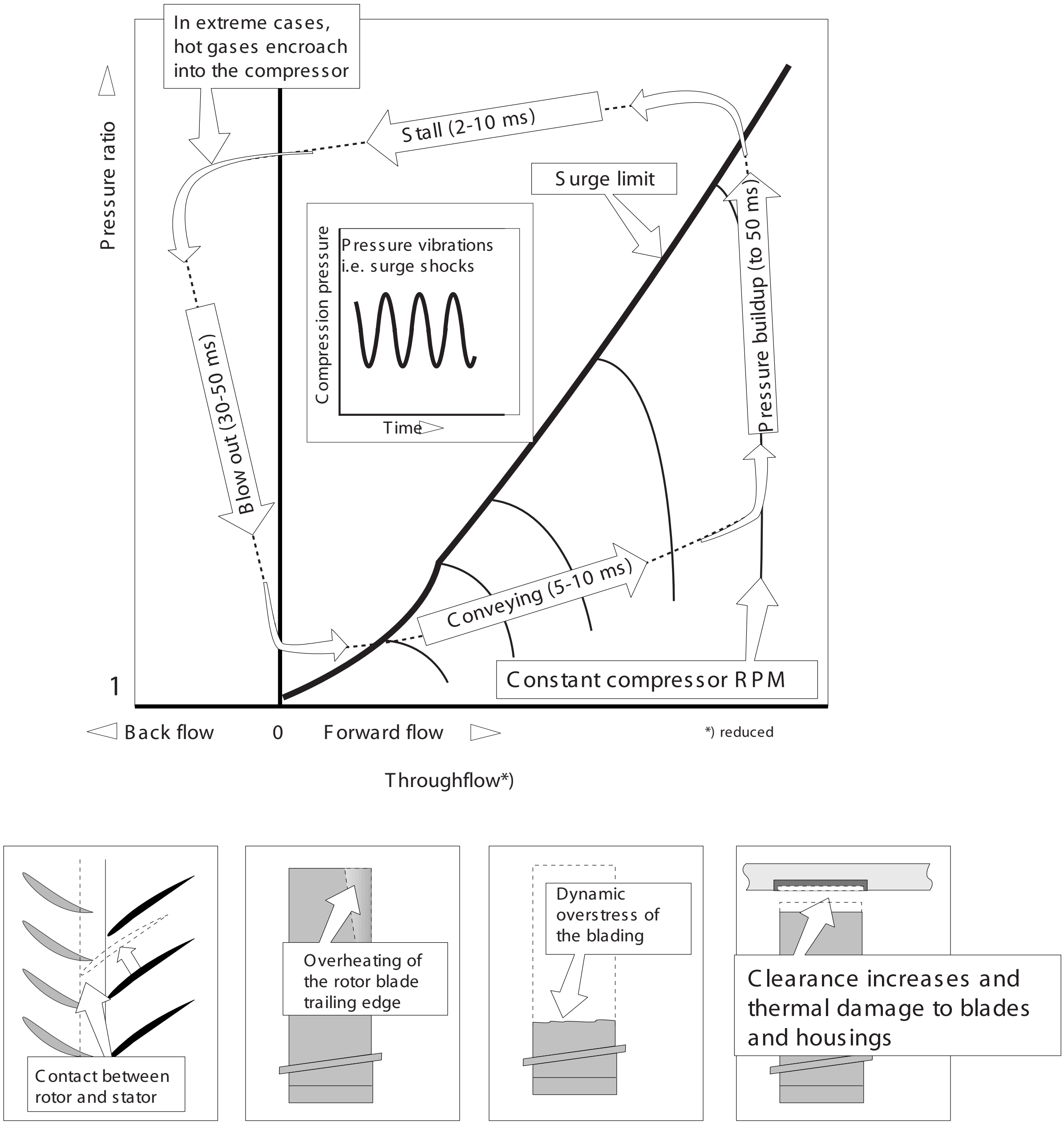
Compressor surges are accompanied by heavy pressure shocks and vibrations.



Compressor damage due to extreme surges

Ill. 11.2.1.2-2

*Illustration 11.2.1.2-2 (Refs.11.2.1.2-1, 11.2.1.2-2): **Compressor surges** (also see page 11.2.1.1-5) are the most common type of compressor instability. A surge is a very high-energy, rotationally asymmetrical process (Ref. 11.2.1.2-2) that can be detected as a **low-frequency vibration** (5-30 Hz; Ill. 11.2.1.3-3). It is caused by a repeating **flow disruption around the entire circumference. Detonation-like sounds** with shock-like engine vibrations are typical of surges. This process occurs when the surge limit is reached, and its mechanism can be explained as follows:*
*Similar to rotating stalls, a local stall zone is created, but it spreads across the entire circumference and **does not rotate.** If the required compressor exit pressure can no longer be reached, it results in stall throughout the entire compressor. This creates a **pressure wave that travels towards the engine inlet at the speed of sound (Ills. 11.2.1.2-3 and 11.2.1.2-4)**, while the air throughput either ceases completely or even results in an airflow towards the inlet caused by the combustion chamber emptying itself "upstream" through the compressor (in extreme cases, with **escaping flames**). The decrease in pressure causes the airflow to resume its normal course so that the compressor again begins to move air. If an end pressure is reached that is above the surge limit, then the described process continues to repeat itself until the cause of the stall is removed.*
*However, there are also cases of **unstoppable surges** (**lock-in surge**; Ill. 11.2.1.2-14). These can be caused by, for example, serious compressor damage due to foreign objects or a fatigue fracture in a blade. Other possible causes include faulty regulators that do not react correctly to the pressure changes caused by a stall. In the case of a **lock-in surge during a rotating stall at low RPM**, interrupting the fuel flow for at least 1-2 seconds (**fuel blipping**) can solve the problem. If this is not sufficient, then the **engine must be shut down and restarted.***

At higher RPM** rates, the external surroundings must be altered. Typical measures include changing the **thrust nozzle position** or **preventing inlet flow disturbances.
Understandably, lock-in surges lead to extreme dynamic loads with various consequences:

- Deflection of the blading that can cause interference of rotor and stator blades (1).

- Blade vibrations leading to blade failures (2).

- Rotor vibrations due to asymmetrical pressure distribution (Ill. 11.2.1.2-3), resulting in dangerous rubbing.

- Powerful axial bearing forces created by the pulsating pressure build-ups and drops (Ill. 11.2.1.2-3).

- Extreme stress on the engine suspension due to shock-like forces and torsion moments (Ill. 11.2.1.2-3).

- Clearance changes at the blade tips and in seals. Pulsating forces on the rotors and housings cause dangerous rubbing. If large radial clearance gaps (3) are created by material removal, the surge limit will be permanently lowered.

- Overheating and erosion of the trailing edges of blades, due to the gas flow expanding forward from the combustion chamber, and/or an "agitation flow" (Ill. 11.2.1.2-5) that transforms the thrust power of the turbine into heat in a very ineffective manner.