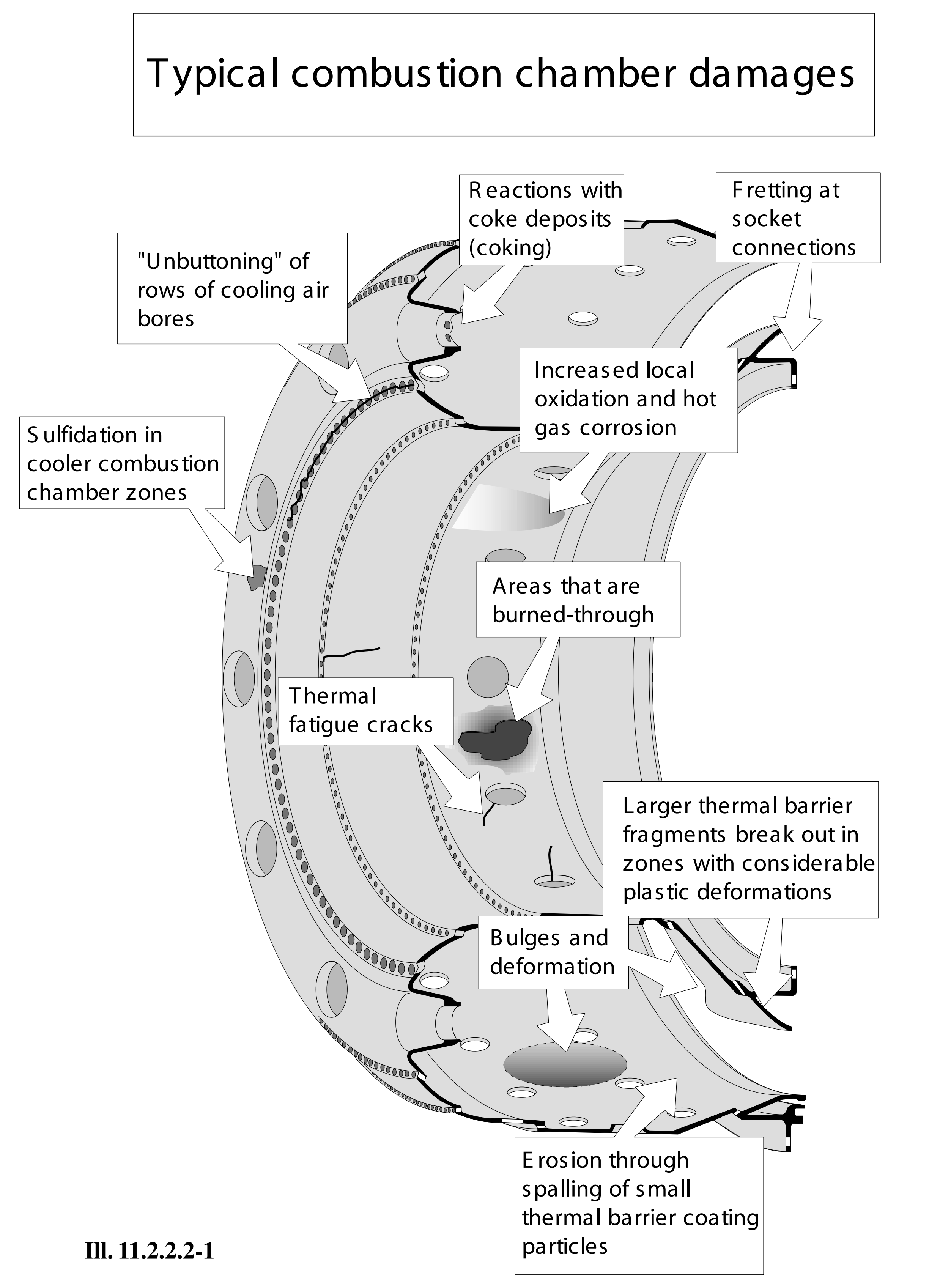
***Illustration 11.2.2.2-1: Damage mechanisms** that affect the inner wall of a combustion chamber:*

*The large temperature gradients between cooled and uncooled combustion chamber zones cause **plastic deformations** when expansion is restricted. A typical symptom is **buckling** of the combustion chamber wall. The thin-walled, ring-shaped lips that create the cooling air film are especially susceptible to buckling (Ill. 11.2.2.3-2). If the temperature changes cause cyclical loads in the plastic zone, it is referred to as **thermal fatigue** (see Chapter 12.6.2). This results in fatigue cracking (LCF, see Chapter 12.6.1). Openings for the cooling air film in the combustion chamber inner wall are commonly affected. In older engine types, the edges of **combustion chamber gills** (bulging slits, Ill. 11.2.2.2-2) crack. Newer combustion chamber models are outfitted with rows of holes that tend to **"unbutton"**. Thermal fatigue cracks also form at larger bores for the combustion air. All of these cracks usually occur in cross-sections with large stress gradients. The average stress in these areas is relatively low, however. For this reason, these **cracks are generally controllable for longer operating times/startup-shutdown cycles.** The maximum allowable crack lengths can vary greatly, depending on the specific parts and engines involved. **Unallowable crack lengths** are reached when the crack growth rate accelerates under additional forces such as gas bending loads or centrifugal force. Fast growth rates are especially dangerous in weakened wall sections with **high-frequency vibrations.** These vibrations can be caused by the typical pulsations during combustion, for example. For this reason, tolerable crack lengths should be limited in low NOx combustion chambers, which are known to have a strongly pulsating combustion process. In **shingle combustion chambers** (Ill. 11.2.2.3-1), dynamic fatigue fractures can cause shingles to break out.*

*Consequential damages from a **wall breakout** occur when, for example, **the flame escapes through the side of the engine.** This can cause the **combustion chamber liner to explode** or block part of the stator. This type of flow disturbance causes **dangerous vibrations of the turbine rotor and/or its blading.***
*Cracking in the combustion chamber wall can create unallowably large **temperature gradients in the hot gas flow at the combustion chamber exit** (Ill. 11.2.2.1-8). This type of cracking is usually the result of asymmetrical combustion and/or localized overheating of the combustion chamber wall due to **hot streaks** (Ill. 11.2.2.1-10) caused by the failure of the cooling air film. Suitable measures such as timely boroscope **inspections** of the combustion chamber and high-pressure turbine make these damages controllable.*
*Unavoidable vibrations caused by the combustion process lead to **fretting wear** (see Volume 2, Chapter 6) in the **socket connections** (for withstanding thermal strain differences) typically used in combustion chambers. Especially pronounced dynamic stress in **low NOx combustion chambers** can cause unallowably high wear rates.*
*Unusually high temperatures accelerate oxidation and emaciation of the walls. In colder combustion chamber areas, sulfur can cause **sulfidation** (Volume 1, Chapter 5.4.5). Coking can minimize damages caused by overheating, but has other, damaging, effects (corrosion).*
*If the combustion chamber wall has a thermal insulation coating, the latter can be expected to **erode** through the delamination of small particles. These particles can wear down the thin diffusion-protection coatings of the turbine blades and considerably reduce their **oxidation life spans.** Larger coating sections delaminate especially through cyclical plastic deformation at the edges of the combustion chamber wall. This results in a temperature increase and accelerated overheating damages. The metal lips that generate the cooling air film are especially susceptible to this type of damage.*


Typical combustion chamber damages
Reactions with coke deposits (coking)
Fretting at socket connections
"Unbuttoning" of rows of cooling air bores
Increased local oxidation and hot gas corrosion
Sulfidation in cooler combustion chamber zones
Areas that are burned-through
Thermal fatigue cracks
Larger thermal barrier fragments break out in zones with considerable plastic deformations
Bulges and deformation
Erosion through spalling of small thermal barrier coating particles

Ill. 11.2.2.2-1