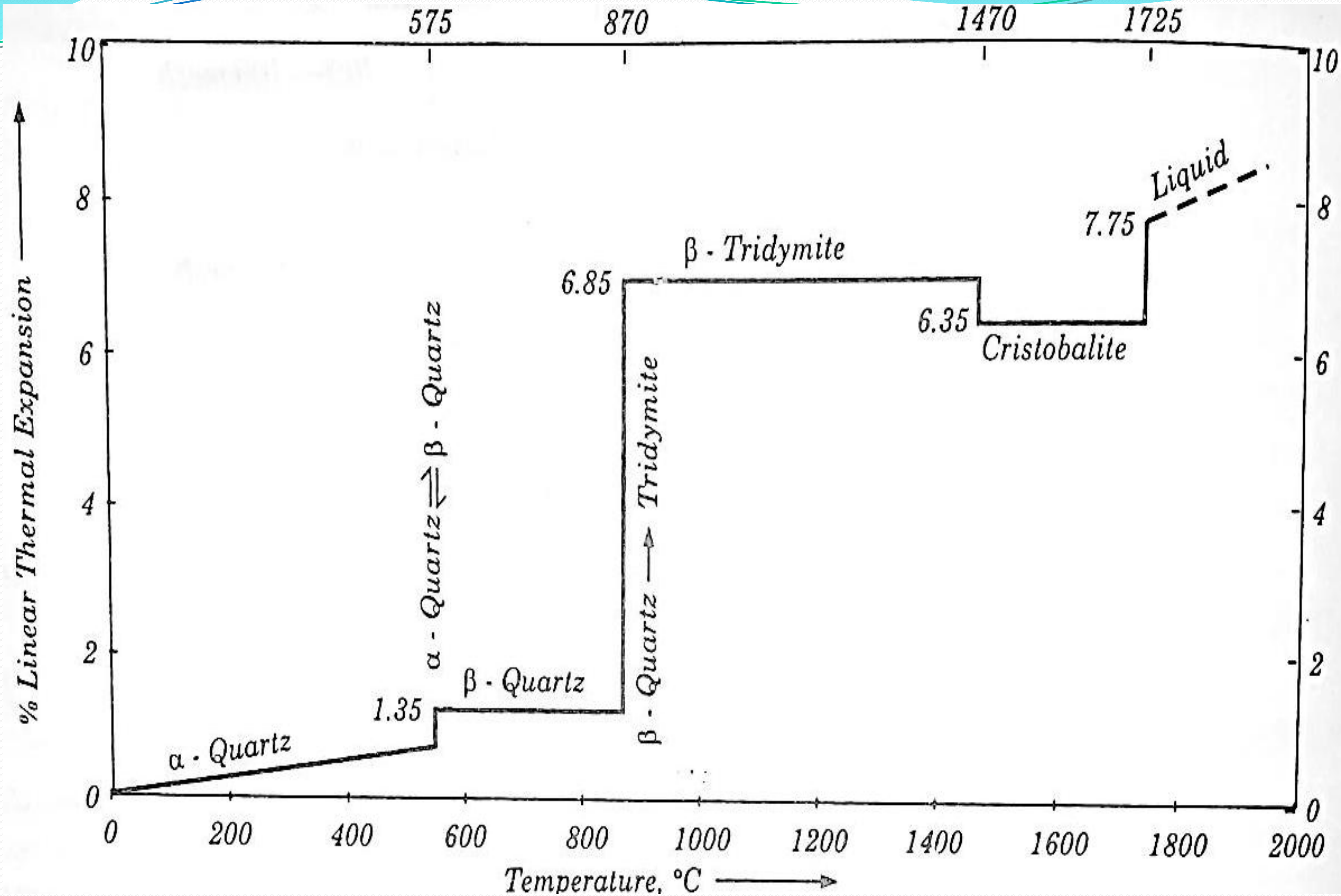
# Types of Refractories
## 3) Silica Refractories

- **3) Silica Refractories:**
- Silica occurs in a variety of crystalline modifications, e.g. ***quartz***, ***tridymite***, and ***cristobalite*** and also as an under-cooled melt called ***quartz glass***.
- The each one of these crystalline modifications have a high and low temperature forms which can transform reversibly.
- The crystal structure of the individual $SiO_2$ modifications can differ widely, so that distinct density changes occur during transformation. This is of great importance during heating and cooling because of the change in the volume.

- The allotropic changes of silica refractory due to heating cause **changes in specific gravity** which in turn cause **changes in volume**.

- These **volume changes** are very important as the stability of silica refractory, when it is subjected to sudden change of temperature.



575
870
1470
1725
10
8
6
4
2
0
% Linear Thermal Expansion
α - Quartz
1.35
α - Quartz ⇌ β - Quartz
β - Quartz
6.85
β - Quartz ⟶ Tridymite
β - Tridymite
6.35
Cristobalite
7.75
Liquid
0
200
400
600
800
1000
1200
1400
1600
1800
2000
Temperature, °C

- The change from **α-quartz** to **β-quartz** from **200°C** to **575°C** is accompanied by change in volume of **4%** (increase).
- At **870°C** when **β-tridymite** is formed, there is increase in volume of **14 to 16%.**
- Conversion of **tridymite** into **cristobalite** is associated with **little contraction** in volume.
- The conversion of silica into cristobalite, that is, heating of silica refractory upto **1470°C** from room temperature is accompanied by an increase of **20%** in volume and the reduction of specific gravity from **2.6 to 2.23**.

- Quartz is the only stable form of silica stable at atmospheric temperature and quartzite is the most used naturally available form of quartz used for making silica bricks.

- Silica refractory generally composites of

  **> 97% $SiO_2$** with **< 3% alkalis** (as impurities), however higher percentages of impurities greatly reduces its refractoriness.

- The American Society for Testing Materials (ASTM) ASTM C416-97, divides silica brick into **Type A** and **Type B** based on the brick's flux factor. Silica brick are classified on the basis of impurities by the use of a "**flux factor**," which is equal to the percent of alumina plus twice the percent of total alkalies.

- **Type A** – includes silica brick with a flux factor of **0.5** or below;
- **Type B** – includes all silica brick with a flux factor above **0.5**.

- Both classes require that brick meet the following criteria:
- $Al_2O_3$ less than 1.5%;
- $TiO_2$ less than 0.2%;
- $Fe_2O_3$, less than 2.5%;
- CaO less than 4%;

- Silica refractories are well adapted to high temperature service because of their high refractoriness, high mechanical strength and rigidity, as well as their ability to resist the action of dusts, fumes and acid slags.

- **Silica Brick Refractory Properties:**
- **Refractoriness.**
- The best silica refractory has softening temperature from 1715°C to l730°C.

- **Refractoriness under load.**

**RUL** and **PCE** values of silica bricks are **very close**.

- **Spalling**
- Sudden changes in temperature causes fine cracks in silica bricks and thus cause disintegration or spalling.
- The spalling is due to the following reasons:

1. Cracks occur in the refractory if the conversion from **quartz** to **cristobalite** or **tridymite** is **incomplete** and if this conversion occurs suddenly due to rapid rise in temperature of the refractory.

This type of spalling can be avoided by repeatedly raising the temperature of the refractory at a slow rate up to 800°C and then cooling it slowly.

2. Cracks occur due to the reversible **expansion** and **contraction** occurring too rapidly. This can also be avoided by heating the refractory slowly.
3. Spalling may occur due to the action of slags.
4. Stresses are created when silica brick is cooled below 250°C due to inversion of cristobalite.

- In general, the **spalling can be decreased** in silica refractory by adopting the following means:

1. By repeatedly heating the refractory to 800°C and then allowing it to cool slowly. By so doing, quartz is changed into tridymite rather than cristobalite.
2. By using a coarse-grained refractory.
3. By increasing the porosity and decreasing the density.

- **Mechanical strength**
- Mechanical strength varies from **250-450 kg/cm$^2$** depending upon its composition.

- The crushing strength (CCS) of silica brick is proportional to fineness of quartz employed, proportion of water added to make paste and the proportion of the binding material added.

- **Characteristics of a good silica brick refractory:**

1. **Refractoriness** should be as high as **1690°C**.
2. The percentage of **silica** should be as high as possible and percentage of other oxides should be very low.
3. It should have **high crushing strength**.
4. There should **not be any volume changes** as far as possible when it is used.
5. It should have as **little spalling** as possible when subjected sudden change of temperature.

- **Manufacture of Silica Refractories:**
- Silica brick is made of **silica** containing more than **96% $SiO_2$** , with addition of **mineralizing agent** (such as iron scales, lime) and **binder** (such as molasses), by kneading, shaping, drying and calcining.
- The raw materials are **crushed** and then **shaped** into the desired shape. After shaping, the products are **dried** in the tunnel kiln at about **120°C** and then **fired at 1500°C**.

- **Effect of Aluminas and Alkalies:**
- After firing, silica brick contain a small proportion of **silicates** in the body that is otherwise crystalline silica.

- Upon being reheated to high temperatures, these **silicates melt** and form a small amount of liquid. As the temperature rises, the liquid increases because the silica also melts, at first slowly and then more rapidly, especially above (1600°C).

When relatively **small amounts of silicate** liquid are present, the solid crystalline portion of the brick forms a rigid skeleton, with liquid merely present between the solid particles, and the brick as a whole retains its rigidity even under load.

When **larger amounts of liquid** develop at higher temperatures, the bond weakens and the brick may lose its rigidity.

- **Uses of Silica Refractory:**

1. Silica refractories are used in the **lining** of furnaces for arches, crowns and higher parts of furnaces and kilns, that is, in portions which are the hottest in furnaces.
2. In glass industry.
3. Silica bricks are used in roof and burner parts of the furnaces. Because of their excellent resistance to compressive stresses at high temperature.