



# **KEPITAL Physical & Mechanical properties**

The physical and mechanical properties measured by standard test methods should be the principle guideline to select material from an engineer's standpoint.

It is also important to review both short-term (strength, modulus, elongation and impact strength etc) and long-term properties (creep, stress-relaxation and fatigue etc) in determining which material to use.

This is because of the fact that plastic materials are affected by various factors such as temperature, stress and time.

## 1. Behavior under short-term stress

The short-term properties of plastics under stress are determined by means of stress measurements in tensile/flexural or sudden blow impact strength, depending on the materials' characteristics, level of the stress, loading speed, temperature and chemical environment.

However, long term properties show time-dependent behavior.

From the tensile test (ISO 527), such data like elastic Young's modulus, strength, and elongation at yield and break point can be obtained.

Those properties are determined from the stress and strain curve (S-S curves) that shows elastic and plastic behavior of a material under a dynamic load.

When the stresses are removed within the elastic limit, a thermoplastic is capable of recovering its original shape.

But on the other hand, if the stress is greater than the elastic limit, the material is deformed permanently after reduction of the stress.

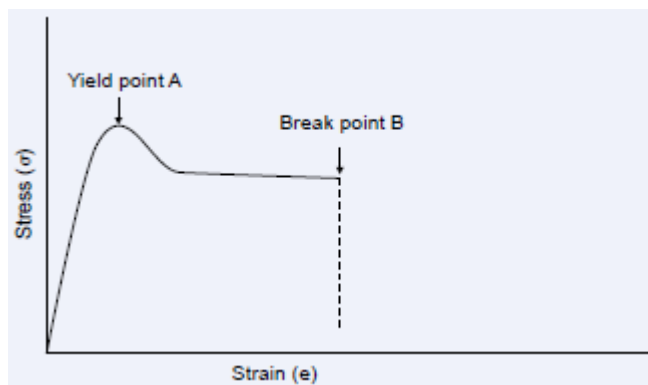


Figure 1. Tensile Stress-Strain curve

In the graph, A is the yield point and its yield stress represents the stress limit for elastic strain.

In the graph, B is the break point at which fracture occurs.

The tensile strength notes the maximum stress ( $\sigma_{max}$ ) in the stress-strain curve (S-S curve). Whereas, when fractured before the yield point, the maximum stress is called the tensile strength and there is no yield stress such as in some cases of reinforced and filled grades.

## 2. KEPITAL stress-strain curve

S-S curves of KEPITAL in tensile and maximum stress, representing tensile strength are shown in Figure 2 and in the following table.

(ISO 527, Temp. 23 °C)

Grade	Tensile strength (MPa)	Testing speed (mm/min)
F20-03	65	50
FG2025	160	50
TE-24	41	50

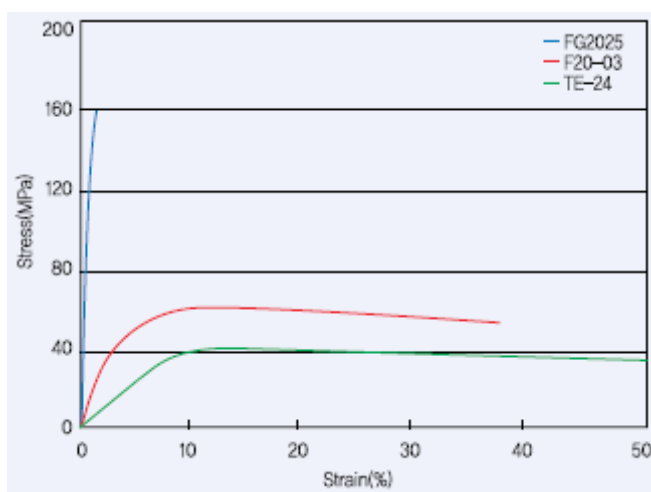


Figure 2. Tensile stress-strain curves for KEPITAL (ISO 527, Temp. 23°C)

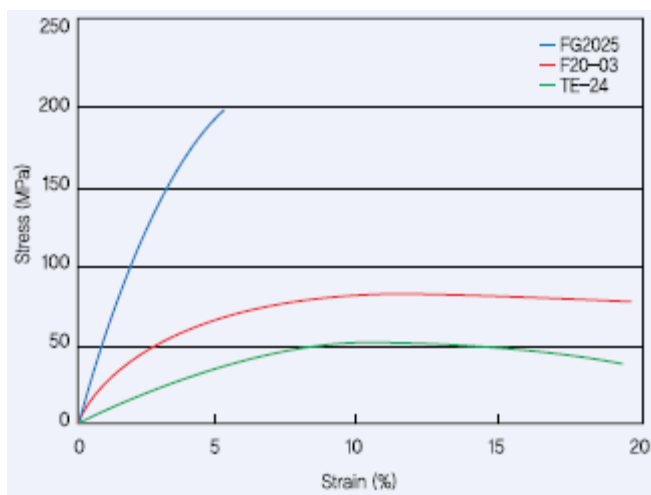


Figure 3. Flexural stress-strain curves for KEPITAL  
(ISO 178, Temp. 23°C, Testing speed 2.0 mm/min)

### 3. Temperature dependency on mechanical properties

KEPITAL maintains balanced physical and mechanical property characteristics over a wide range of temperatures.

Figure 4 shows stress-strain curves of tensile tests at various temperatures, and Figure 5 shows dependence of the tensile strength on temperature.

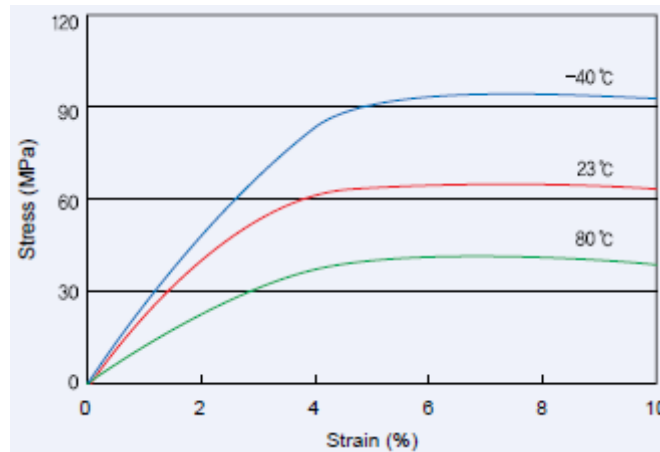


Figure 4. Stress-strain curves of F20-03 at various temperatures (ISO 527, Testing speed 50 mm/min)

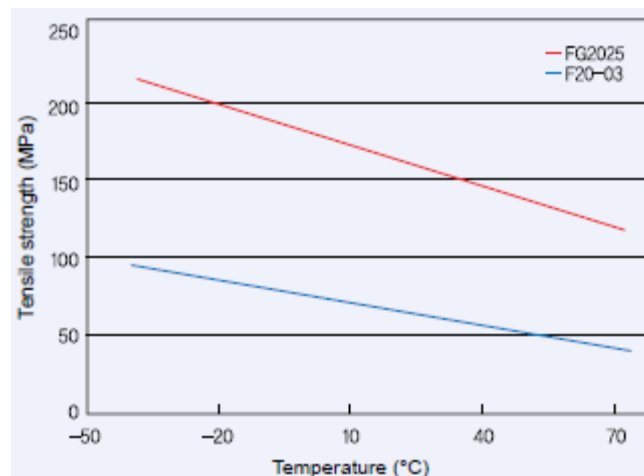


Figure 2-5. Tensile strength of KEPITAL versus Temperature (ISO 527, Testing speed 50 mm/min)

### 4. Impact strength

The impact strength is the energy to withstand a dynamic impact rather than static stress.

There are several ways to evaluate impact strength, and the Charpy(ISO 179) and Izod (ASTM D256) tests are mostly used to determine the toughness of plastic materials.

The impact strength can be measured in either notched or un-notched sample; however, it is generally evaluated after notch-processed on a specimen so that the stress of an impact load may be concentrated.

KEPITAL has good impact resistance at low temperatures(-30 to -20 °C) as it has a very low glass transition temperature below -40 °C.

Grade	F20-03	FG2025	TE-24
Impact strength (kJ/m <sup>2</sup> )	6.5	8	18

Table 1. Notched Charpy impact strength of KEPITAL (ISO 179, 23°C)

## 5. Shear strength

The maximum shear stress at which a material can be maintained prior to shearing (punching) is referred to as shear strength.

The shear strength represents the maximum load required to completely shear a sample by the maximum strength of a material that is influenced by shear stress.

The shear strength is determined by dividing the force required to shear the specimen by the area of the sheared edge. (ASTM D732)

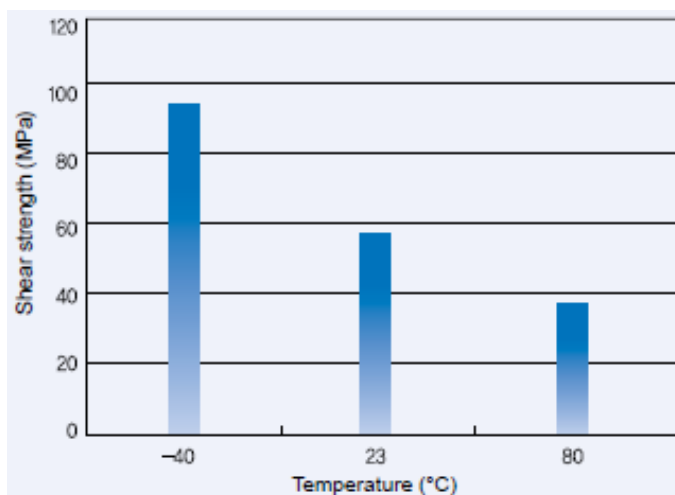


Figure 6. Shear strength of KEPITAL F20-03 at various temperatures (ASTM D732, t 3 mm, testing speed 1.25 mm/min)

## 6. Specific volume

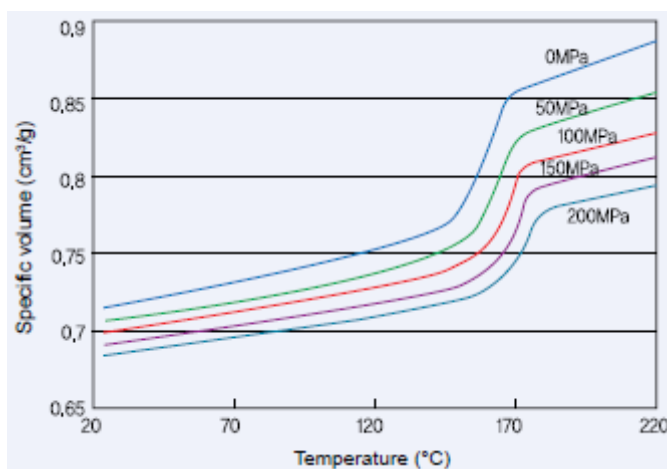


Figure 7. P-v-T curves of KEPITAL F20-03

As shown in Figure 7, the molding shrinkage of KEPITAL results from both its high crystalline alignment in solidification and its thermal shrinkage from the molten state to the solid state as a function of temperature and pressure.

Furthermore, higher cooling rates or cooling under higher pressures causes less volume shrinkage.

Figure 7 notes a steep volume shrinkage of KEPITAL around 160°C in the specific volume curves.

## 2-7. Hardness

The hardness of a plastic material is usually indicated in terms of the Rockwell Hardness which measures surface penetration with a steel ball under specific conditions.

The Rockwell Hardness scale is dependent on ball diameter and load (ASTM D785).

The Rockwell Hardness of a plastic is divided into a M scale or a R scale, and the higher number the higher hardness.

The following figure shows the hardness differences as a function of the viscosity of the standard unfilled grades.

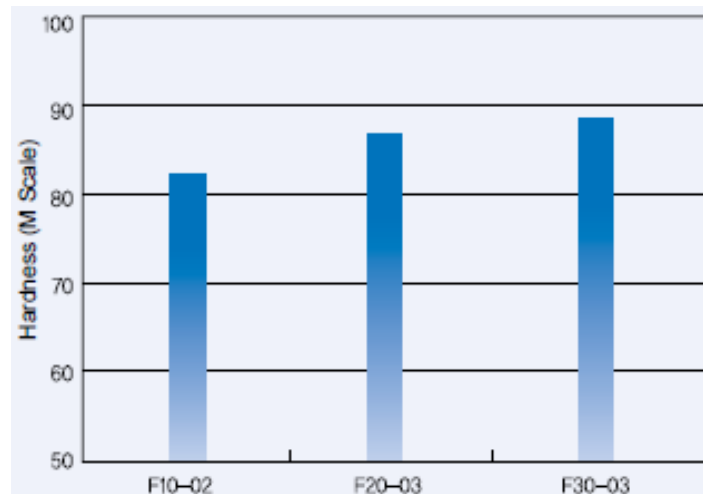


Figure 8. Hardness of standard unfilled grades

The following figure shows the hardness differences of the impact modified grades.

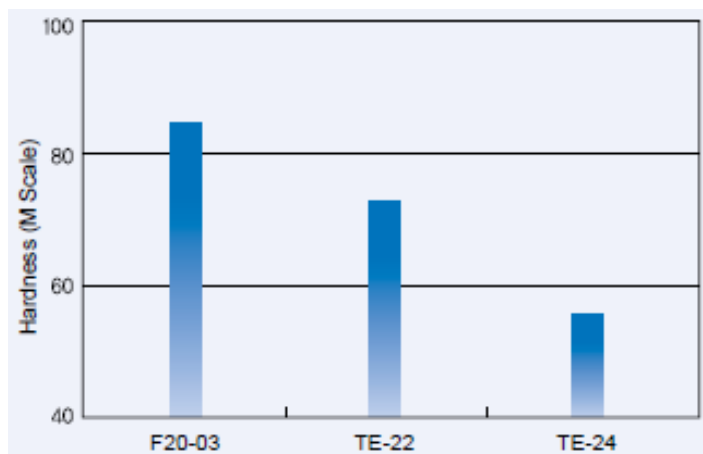


Figure 9. Hardness of impact modified grades

## 8. Poisson's ratio

The Poisson's ratio ( $\nu$ ) is defined as the ratio of the transverse strain to longitudinal strain of plastic materials and it is useful to calculate this physical property in perpendicular direction to loading.

The Poisson's ratio is dependent on time, temperature, stress etc.

The ratio of KEPITAL F20-03 is approximately 0.35.

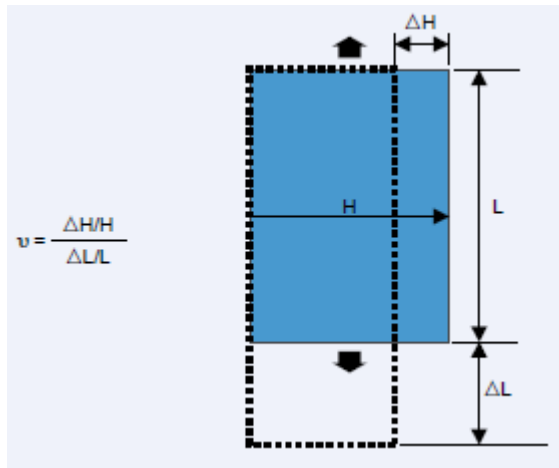


Figure 10. Poisson's ratio

The property values of a material used for structure analysis are tensile modulus ( $E$ ) and the Poisson's ratio ( $\nu$ ).

With the Poisson's ratio ( $\nu$ ) and the tensile modulus ( $E$ ), the material's shear modulus ( $G$ ) can be simply calculated.

It is because a material deforms not only in the tensile direction but also in its perpendicular direction.

$$G = \frac{E}{2(1+\nu)}$$

## 9. Behavior under long-term static stress

When static stresses are loaded to thermoplastics constantly, not only does the initial strain occur but also an incremental strain follows as time goes by due to its viscoelastic property.

The creep is the total strain of initial elastic deformation and plastic flow for loading time.

The creep behavior of KEPITAL is time, temperature and load dependent.

Therefore a resilient material like KEPITAL recovers its original shape entirely or partially when the loaded stress is removed.

The influential factors on KEPITAL

- (1) Stress, environmental factors; temperature, high humidity, chemicals etc.
- (2) Molecular weight and filler content
- (3) Part design

The following figures show the tensile creep characteristics and flexural creep characteristics of KEPITAL.

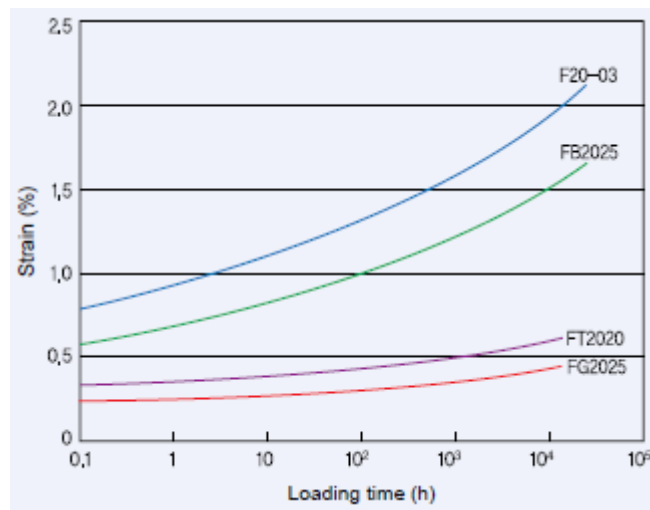


Figure 11. Flexural creep curves of KEPITAL (23°C, 20 MPa)

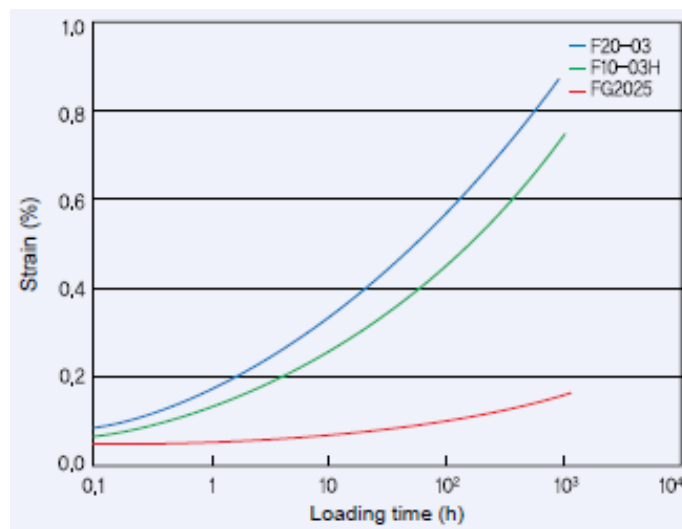


Figure 12. Tensile creep curves of KEPITAL (23 °C, 12 MPa)



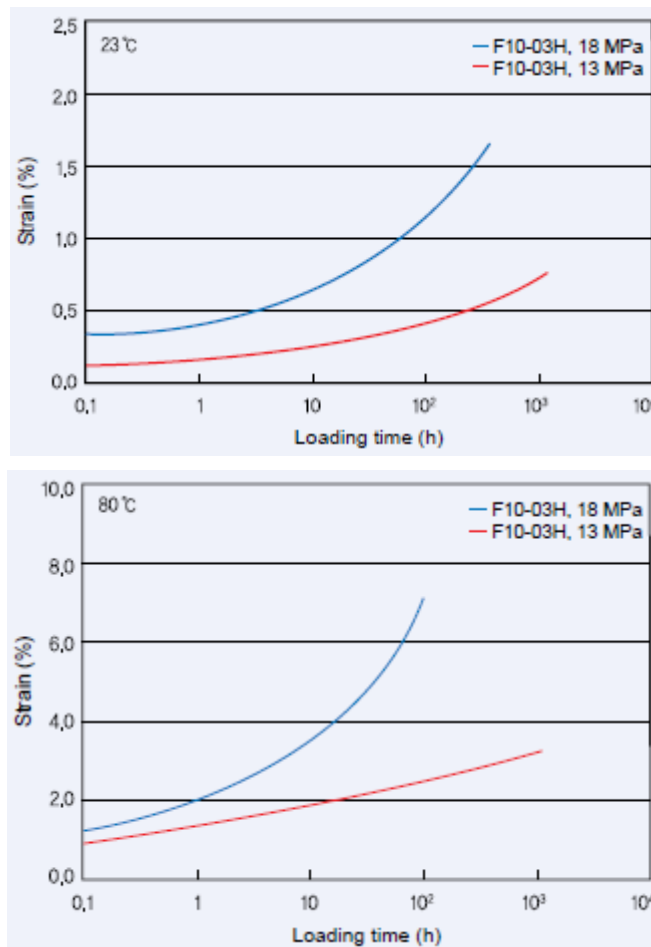


Figure 13. Tensile creep behavior of KEPITAL F10-03H

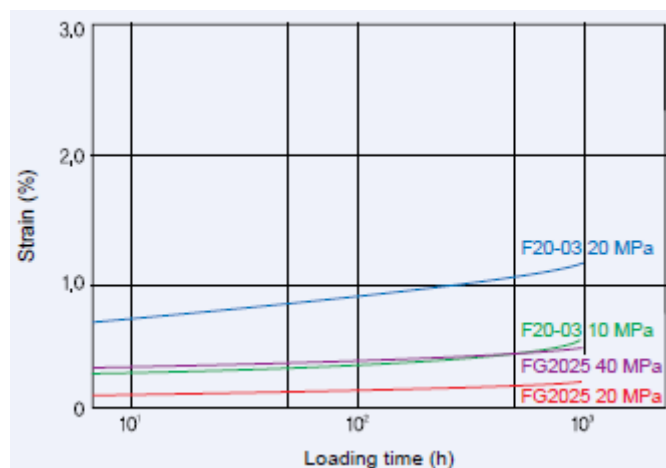


Figure 14. Flexural creep curves of KEPITAL FG2025 and F20-03(23°C)

The creep failure is a phenomenon in which a part strained and then eventually fractures under a constant stress over a long period. Because plastics have viscoelastic properties, creep strain is more readily exhibited than in metallic materials. In particular, when designing parts such as pressure resistant containers, screw fasteners, insert formations and insertion parts for a post-treatment process, the creep property of material must be considered in advance.

Figure 15 shows the creep rupture of KEPITAL F20-03 with various loads and temperatures.

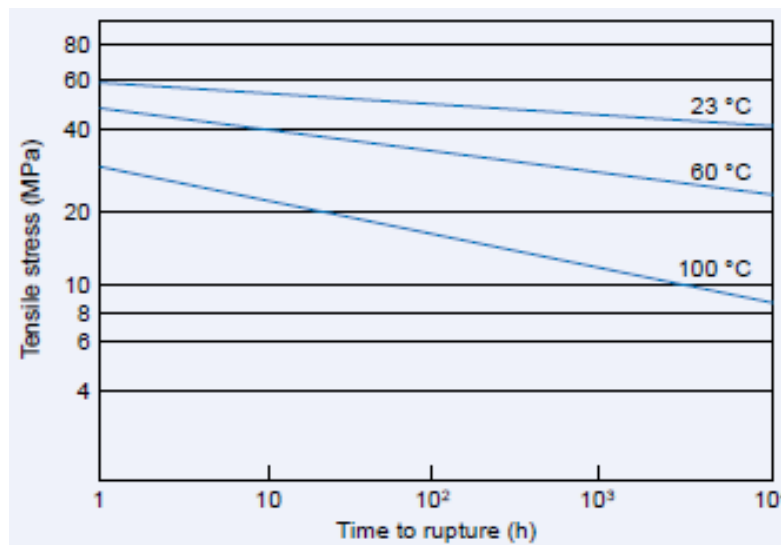


Figure 15. Creep rupture curve of KEPITAL F20-03

## 2-10. Property under cyclic stress

Designing based on a dynamic structure analysis, obtained where a part is subjected to loading once, can only provide information if a part can be used without fracture under the single loading environment.

The engineering parts are often subject to fatigue by stress or strain which is applied repeatedly and periodically over a long period. Fracture or failure that results from this phenomenon is called fatigue failure.

Therefore, when designed, the fatigue properties of a material should be considered.

The fatigue strength of plastics is generally determined without failure and is provided through a S-N curve (Wöhler curve).

The fatigue property is dependent on the frequency and various stress ranges as shown in Figure 16.

In general, there are methods for evaluating the fatigue characteristic of plastics:

- (1) Load control method (Load control)
- (2) Strain control method (Strain control)
- (3) Strain control between grips method (Position control)

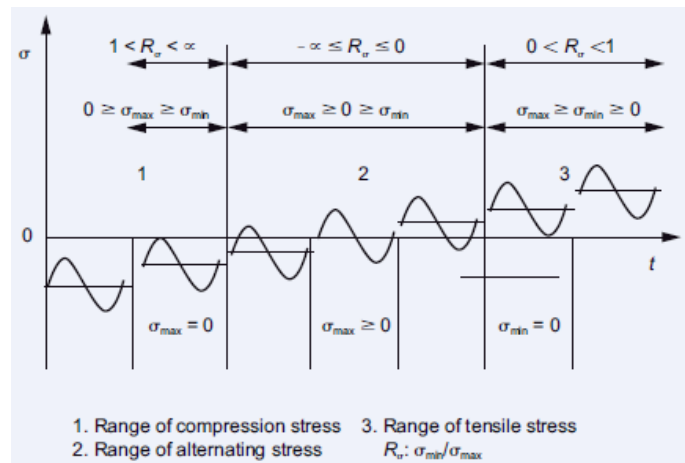


Figure 2-16. Stress range of fatigue test

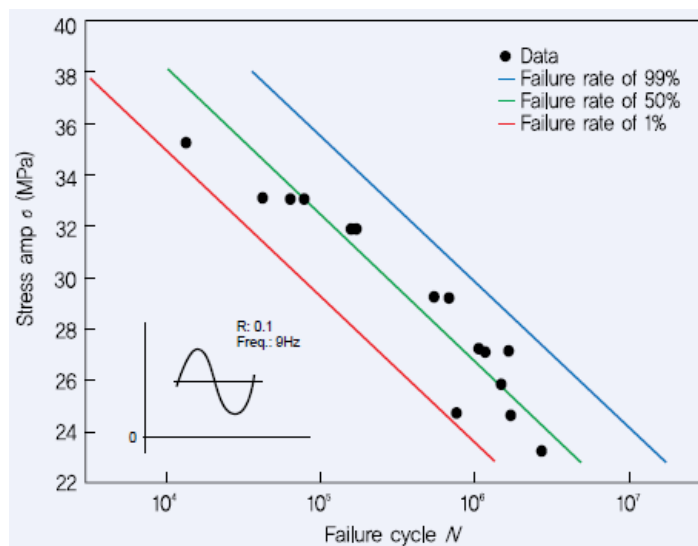


Figure 17 Wöhler curve of KEPITAL FG2025

Figure 18 shows the results of fatigue properties of KEPITAL evaluated based on the strain control method.

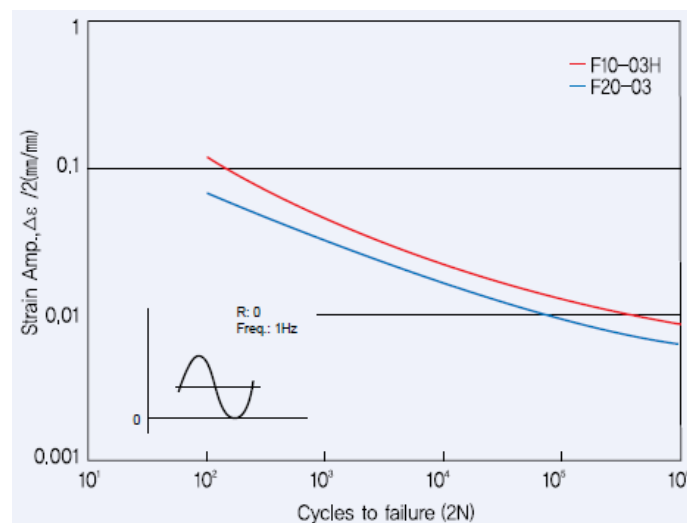


Figure 18. Fatigue properties based on the strain control method for unfilled grades

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