HMK

Crane Service Life

Classification of Cranes

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port technology

Service Life of Cranes – A Brief Explanation of the Basic Terms

Classification of Cranes according to FEM 1.001

Two crucial aspects need to be kept in mind when weighing up the options before purchasing material handling equipment, such as a Mobile Harbour Crane: the maximum handling rates of the crane and its total intended duration of use ("service life").

While great importance is attached to the maximum handling rates in the decision to purchase, too little focus is placed on an assessment of the crane's service life.

For this reason, the basic interrelationships and factors influencing the service life of a Mobile Harbour Crane are explained below.

What Do we Really Mean by Service Life?

When a component or an entire unit, such as a crane, is excessively overloaded, it will fail at once. However, by far the more relevant cause of the damage is failure of the crane due to use beyond its service life.

Each individual work cycle of a crane (even if the load lifted is far below the crane's maximum lifting capacity) contributes to component fatigue. If a load is applied often enough, the component fails even if the individual loads alone did not lead to the failure.

The Paper Clip Experiment

Take a paper clip in your hand and try to tear it apart. It will not be possible. However, if you bend it back and forth several times, even a relatively small force is sufficient to break it. As a result of the repeated loading, the useful life of the paper clip is exceeded because, as with most components in technical applications, it was designed for a finite service life that is not based on fatigue endurance.

With the help of this simple experiment it is easy to understand that both the intensity of the stress (i.e. how powerfully the paper clip was bent back and forth) and the number of bends ("work cycles") are relevant for the time at which the failure occurs.

However, how would a paper clip made of thicker wire behave? Experience from everyday life teaches us that it would have lasted longer. Another aspect for evaluating the service life is thus the durability ("loading capacity") for which a component has been designed.

Two fundamental elements are decisive for evaluating the service life of a component or a crane: the load and the loading capacity. The service life (**Figure 1**) is a result of the interplay of these two components.

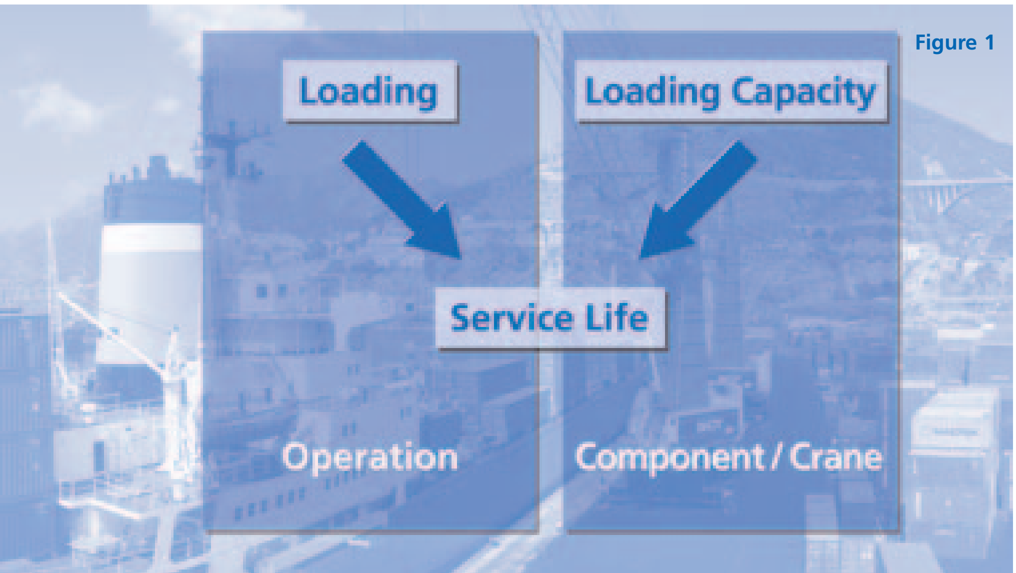

Figure 1

Effects of Loading

The loads acting on a Mobile Harbour Crane during operation are not constant. A distinction is made between different modes of operation (heavy load operation, container operation, grab operation, etc.), in which very different loads occur (empty containers – full containers, empty grabs – full grabs, etc.).

It is, therefore, not possible to assume a constant load for the crane. As a result, the standards according to which a crane is designed (e.g. FEM 1.001) define the loading spectrum by means of which an attempt is made to describe the actual load applied to a crane.

How is a Loading Spectrum Determined?

To accurately determine a loading spectrum for a particular crane, a statistical random check is used. Readings are taken, for example, thousand cycles for a container handling crane and a crane equipped with grab (50 t lifting capacity in each case) as shown in **Figure 2**.

On the basis of these random checks, it is then possible to determine the loading spectrum of the crane examined. However, since the exact distribution of loads in practice is not known in advance, crane manufacturers must apply different criteria when designing a crane.

The standard on which the crane calculation is based, i.e. FEM 1.001, makes it possible to estimate the future loading of a crane and select one of four standardised loading spectra. The standardised load spectrum classes range from Q1 ("crane predominantly lifts low loads and only rarely maximum permissible loads") to Q4 ("crane frequently lifts loads equal to its maximum lifting

Figure 2: Determination of the loading spectra

	Container discharging crane	Crane fitted with grab
Load on ropes [t]	No. of cycles	
10	0	0
12	0	0
14	15	0
16	181	0
18	63	35
20	30	0
22	43	0
24	45	0
26	42	0
28	37	0
30	45	0
32	64	0
34	86	3
36	138	7
38	101	13
40	57	30
42	37	40
44	12	87
46	3	170
48	1	315
50	0	300

capacity"). Therefore, the decisive factor for selection of a spectrum class is how frequently a crane has to lift heavy loads (in comparison to the maximum load in the mode of operation examined).

The diagram in **Figure 2** clearly shows that a crane equipped with a grab, for example, is subjected to significantly higher loads than a container-handling crane because heavy loads occur at a higher frequency (the crane driver almost always fills the grab completely with bulk material). A crane fitted with a grab must therefore always be classified in the highest spectrum class.

Loading capacity

While loading is a characteristic of crane operation, the loading capacity is a characteristic of the crane construction. When a crane is designed, a certain crane classification is selected by the manufacturer and the crane is designed according to this classification.

FEM 1.001 offers a choice of eight group classifications (A1 to A8). In the example above with the service life of a paper clip, we noted that the thickness of the wire is a determining factor for the service life. In the steel structure of a crane the same applies. To put it in very simplified form:

The higher the number of the crane group, the thicker the steel sheet and tubing used and the more robust the crane.

Service Life

If the loading capacity (crane group) and the expected load (spectrum class) are known, the service life (class of utilisation) of the crane can be determined on that basis.

According to FEM 1.001, this will give us a class of utilisation from U0 to U9 and thus an indication of how many work cycles the crane will manage before the end of its service life is reached. Towards the end of the service life, the probability of failure increases rapidly with further operation. The relationship between the sizes, crane group, spectrum class and service life is illustrated in **Figure 3** and **Table 1**. If we now compare a crane in crane group A8 to a crane in crane group A6 with regard to service life, it is easy to determine on the basis of the diagram how long the useful life of each one will be.

If both cranes are used for the same type of application, the same spectrum class applies to both cranes. If this class is specified as Q3, it can be seen that the crane classified in A8 will have a service life of more than 4,000,000 work cycles whereas the crane classified according to A6 will reach the end of its service life after only 500,000 work cycles.

The crane with the higher classification thus has a useful life that is over four times longer given the same loads! As a rule of thumb, one can state on the basis of the diagram in **Figure 3.**

Given the same loads, an increase in the crane group by one level (e.g. from A6 to A7) corresponds to a doubling of the expected useful life.

Cranes that have been classified in the highest crane group, A8, are designed such that the loads on the components during operation are so low that theoretically no fatigue is caused by such operation.

Consequently, a crane classified in crane group A8 does not have a limited service life and will have an unlimited fatigue endurance.

Figure 3: Relationship between crane group and useful life

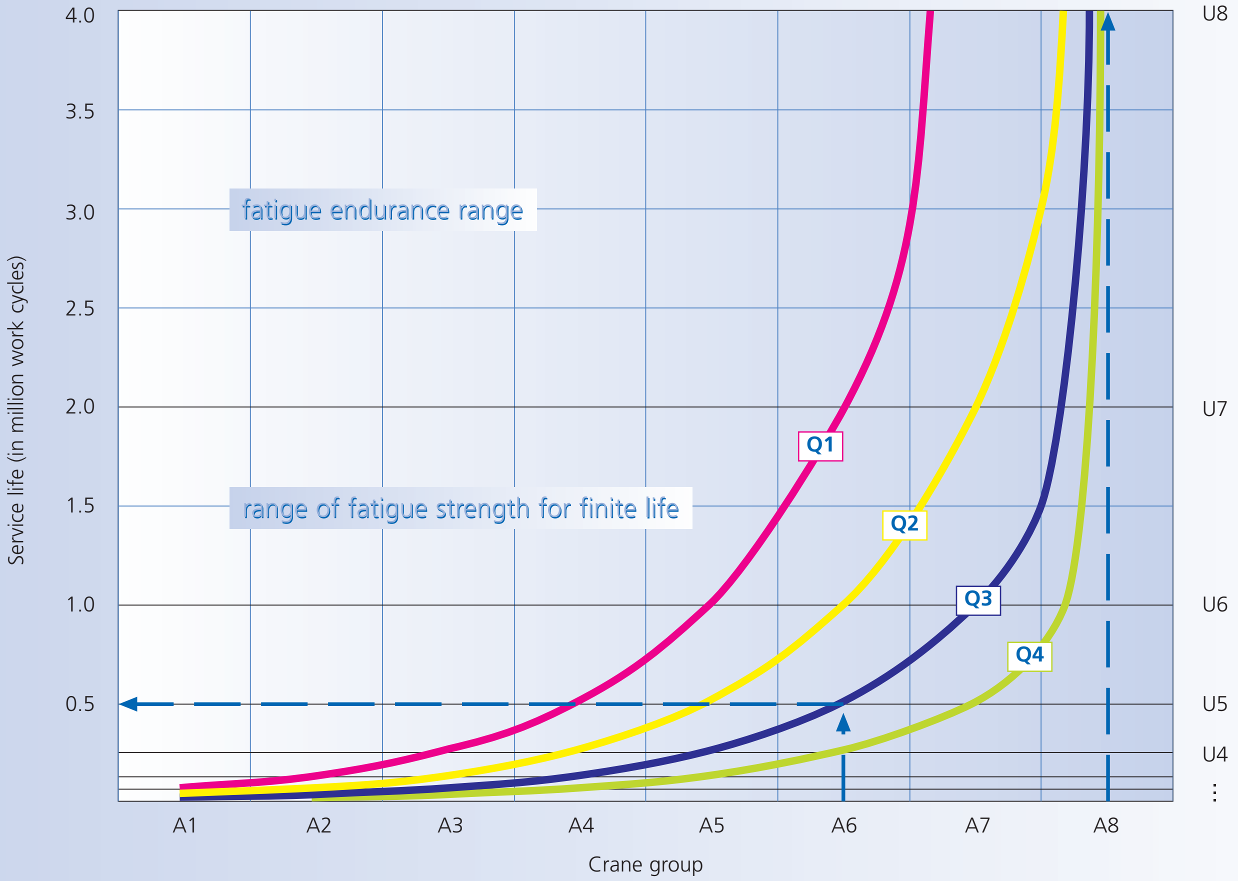

Table 1

Loading spectrum class	Class of utilisation and duration of use (number of work cycles)									
	U0	U1	U2	U3	U4	U5	U6	U7	U8	U9
	16,000	32,000	63,000	125,000	250,000	500,000	1 m	2 m	4 m	> 4 m
Q1	A1	A1	A1	A2	A3	A4	A5	A6	A7	A8
Q2	A1	A1	A2	A3	A4	A5	A6	A7	A8	A8
Q3	A1	A2	A3	A4	A5	A6	A7	A8	A8	A8
Q4	A2	A3	A4	A5	A6	A7	A8	A8	A8	A8

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