FEM

European Materials Handling Federation

www.fem-eur.com

Product Group /

Cranes & Lifting equipment

subgroup Electric Overhead Traveling Cranes

12.12.19

N 9.521

(First Edition)

Guideline -
Classification of Cranes and Lifting Equipment

Content

1. INTRODUCTION

Historically, hoists and lifting equipment were classified according to time-based methods as found e.g. in FEM Guidelines or ISO Standards. In recent years, cycle-based classification has become more and more common as the new EN 13001 series, e.g. EN 13001-1:2015, EN 13001-2:2014, EN 13001-3-1:2012 [1-3] and ISO 4301-1:2016 [4] was published. The mode of calculation used for the EN 13001 has been partly adopted at EN and ISO level, and important standards like the EN 14492-2 [5], EN 15011 [6], EN 13135 [7], ISO 16625 [8] and others are currently under revision.

This FEM Guideline aims to help purchasers of hoists and lifting equipment, users and manufacturers understand the relationship between both types of classification by explaining the method for converting time-based into cycle-based classification (and vice versa) developed by Prof. Dr.-Ing. Markus Golder and Prof. Dr.-Ing. Gerhard Wagner [9] and showing typical examples for illustration.

Comparing the classifications and determining the matching classes does not necessarily mean that the products designed based on different standards are equivalent to each other.

The results of design calculations of e.g. steel structure, hooks or ropes will most probably differ.

Explanatory Note:
This publication is only for guidance and gives an overview regarding the assessment of crane and lifting equipment classifications and their conversion. It neither claims to cover every aspect of the matter, nor does it reflect all legal aspects in detail. It is not meant to, and cannot, replace own knowledge of the pertaining directives, laws, regulations and standards. Furthermore, the specific characteristics of the individual products and the various possible applications have to be taken into account. This is why, apart from the assessments and procedures addressed in this guide, many other scenarios may apply.

2. TIME BASED M-CLASSIFICATION VS. CYCLE-BASED A-CLASSIFICATION [9]

Although parts and components of a mechanism or structure are worn by stress cycles, a time-based classification has been state-of-the-art and preferably used by manufactures and operators of hoists. Time based classification is done according to M-classes. Table 1 shows the classification method.

Group classification M of a mechanism as a whole (according ISO 4301-1:1986, FEM 1.001 Booklet 2:1998)																
		Class of utilization t_T [h] of the mechanism and Classes T														
		$t_T \leq 6.25$	$t_T \leq 12.5$	$t_T \leq 25$	$t_T \leq 50$	$t_T \leq 100$	$t_T \leq 200$	$t_T \leq 400$	$t_T \leq 800$	$t_T \leq 1600$	$t_T \leq 3200$	$t_T \leq 6400$	$t_T \leq 12\,800$	$t_T \leq 25\,600$	$t_T \leq 51\,200$	$t_T \leq 102\,400$
State of loading	Load spectrum factor K_m	(T05)	(T04)	(T03)	(T02)	(T01)	T0	T1	T2	T3	T4	T5	T6	T7	T8	T9
Extreme light	$0.0000 < K_m \leq 0.0313$						(M03)	(M02)	(M01)	(M0)	M1	M2	M3	M4	M5	M6
Very light	$0.0313 < K_m \leq 0.0625$					(M03)	(M02)	(M01)	(M0)	M1	M2	M3	M4	M5	M6	M7
Light	$0.0625 < K_m \leq 0.1250$				(M03)	(M02)	(M01)	(M0)	M1	M2	M3	M4	M5	M6	M7	M8
Moderate	$0.1250 < K_m \leq 0.2500$			(M03)	(M02)	(M01)	(M0)	M1	M2	M3	M4	M5	M6	M7	M8	(M9)
Heavy	$0.2500 < K_m \leq 0.5000$		(M03)	(M02)	(M01)	(M0)	M1	M2	M3	M4	M5	M6	M7	M8	(M9)	(M10)
Very heavy	$0.5000 < K_m \leq 1.0000$	M(03)	(M02)	(M01)	(M0)	M1	M2	M3	M4	M5	M6	M7	M8	(M9)	(M10)	(M11)
Total duration of use full loaded T_f [h] and classes of M		6,25	12,5	25	50	100	200	400	800	1600	3200	6300	12 500	25 000	50 000	100 000

Table 1: Group classification M of a mechanism. Note: (T), (M) not defined by a standard [9], based on [10, 11]

The total duration of use t_T is classified according to T-classes. The load is given by a load spectrum factor K_m. The correlation of t_T respectively T-class and K_m leads to M-classes. The cycle-based classification for structures is carried out according to A-Classes. Table 2 shows the classification method.

Classes A for group classification (according ISO 4301-1:2016)																
		Total number of working cycles C [-] and Classes U														
		C ≤ 500	C ≤ 1000	C ≤ 2000	C ≤ 4000	C ≤ 8000	C ≤ 16 000	C ≤ 31 500	C ≤ 63 000	C ≤ 125 000	C ≤ 250 000	C ≤ 500 000	C ≤ 1 000 000	C ≤ 2 000 000	C ≤ 4 000 000	C ≤ 8 000 000
State of loading	**Load spectrum factor K_p**	**(U05)**	**(U04)**	**(U03)**	**(U02)**	**(U01)**	**U0**	**U1**	**U2**	**U3**	**U4**	**U5**	**U6**	**U7**	**U8**	**U9**
Extreme light	$0.0000 < K_p \leq 0.0313$						A03	A02	A01	A0	A1	A2	A3	A4	A5	A6
Very light	$0.0313 < K_p \leq 0.0625$					A03	A02	A01	A0	A1	A2	A3	A4	A5	A6	A7
Light	$0.0625 < K_p \leq 0.1250$				A03	A02	A01	A0	A1	A2	A3	A4	A5	A6	A7	A8
Moderate	$0.1250 < K_p \leq 0.2500$			A03	A02	A01	A0	A1	A2	A3	A4	A5	A6	A7	A8	A9
Heavy	$0.2500 < K_p \leq 0.5000$		A03	A02	A01	A0	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10
Very heavy	$0.5000 < K_p \leq 1.0000$	**A03**	**A02**	**A01**	**A0**	**A1**	**A2**	**A3**	**A4**	**A5**	**A6**	**A7**	**A8**	**A9**	**A10**	**A11**
Number of full loaded cycles C_f [-] and classes of A		500	1000	2000	4000	8000	16 000	31 500	63 000	125 000	250 000	500 000	1 000 000	2 000 000	4 000 000	8 000 000

Table 2: Classes A for group classification. Note: (U) not defined by a standard [9], based on [4]

The total number of working cycles C is classified according to U-classes. The load is given by a load spectrum factor K_p. The correlation of C respectively U-classes and K_p leads to A-classes.

3. TRANSFORMATION OF CLASSIFICATION [9]

For the transformation of time-based classification into cycle-based classification, it is important to make **appropriate assumptions**:

1. The first essential parameter is the **average cycle time $\boldsymbol{t_{av}}$**. Each displacement of a load takes a certain amount of time. This time is calculated from the average hoisting displacement and the average speed during this displacement:

$$\boldsymbol{t_{av}} = \frac{2\times \textbf{\textit{average hoisting displacement}}}{\textbf{\textit{average hoisting speed}}} \quad (3.1)$$

2. The second important parameter is the **drive utilization $\boldsymbol{\alpha}$**: α describes the ratio between the duration of the cycle with load for the displacement and the average cycle time. Typical values for α are:
    - If the load is lifted and lowered during the same working cycle, $\boldsymbol{\alpha = 1.0}$ can be assumed in most cases. This is typical for hoists of **industrial cranes**.
    - If the load is only lifted or lowered during a working cycle, $\boldsymbol{\alpha = 0.5}$ can be assumed in most cases. This is typical for **tower cranes** and **mobile cranes.**
    - For other hoisting mechanism α could vary depending on the application.

The use of average time and a utilization factor for transformation is not a new concept: FEM 1.001 Booklet 2 [11] introduced these factors and the possibility to transform cycles to time.

The method to transform time-based classification into cycle-based classification is shown in (3.2):

$$\boldsymbol{M \rightarrow \left(\frac{T_f}{K_m}\right) \times \left(\frac{1}{\alpha}\right) \times \left(\frac{1}{t_{av}}\right) \times K_p = C_f \rightarrow A} \quad (3.2)$$

The selection of an M-class determines the total duration of use T_f under full load. The number of working cycles C can be calculated from the load spectrum factor K_m, the drive utilization α and the assumed average cycle time t_{av}. The amount of working cycles leads to the corresponding U-class. U-class correlated with K_p leads to the corresponding A-class. The amount of working cycles C_f under full load may be directly calculated from (3.1).

The choice of either K_m or K_p as load spectrum factors depends on the respective standard since different standards take different loads into account. Very often, K_m for the mechanism takes dead loads into account, whereas K_p very often is calculated without dead loads. EN 15011 [6] shows the relationship between K_m and K_p and suggests how to convert e.g. K_p into K_m.

The method to transform cycle-based classification into time-based classification is shown in (3.3):

$$\boldsymbol{A} \rightarrow \quad \left(\frac{\boldsymbol{C_f}}{\boldsymbol{K_p}}\right) \times \boldsymbol{t_{av}} \times \boldsymbol{K_m} \times \boldsymbol{\alpha} = \boldsymbol{T_f} \quad \rightarrow \boldsymbol{M} \tag{3.3}$$

The selection of an A-class determines the amount of working cycles C_f under full load. The total duration of use t_T can be calculated from the load spectrum factor K_p and the assumed average cycle time t_{av}. The total duration of use leads to the corresponding T-class. T-class correlated with K_m and α leads to the corresponding M-class. The total duration of use full loaded T_f may be directly calculated from (3.3).

4. INFLUENCE OF PARAMETER t_{av} ON CONVERSION (SENSITIVITY ANALYSIS)

The following general example of a hoisting application illustrates the conversion method described in chapter 3 and emphasizes the influence of different parameter values.

To perform a simple sensitivity analysis on t_{av}, the following initial settings are made:

- average hosting displacement is $6m$;
- average hoisting speed is $5m/min$;
- during a working cycle the same load is lifted and lowered, therefore $\alpha = 1.0$;
- the total duration of use under full load $T_f = 1{,}000$ (classified as M5, refer to Table 1);
- for simplification purposes K_m and K_p are considered equal, the load spectrum is considered "very heavy" and therefore K_m and K_p are set to value 1.

Special care needs to be taken when using heavy load lifting attachments such as beams, magnets, spreaders.

Based on the given information, t_{av} could be calculated applying formula (3.1):

$$t_{av} = \frac{2 \times \ average\ hoisti \quad displacement}{avera \quad hoisting\ speed} = \frac{2 \times 6m}{5m/min} = 2.4min = 0.04h$$

Now, the conversion from time-based classification into cycle-based classification ($M \rightarrow A$) is illustrated applying formula (3.2):

$$C_f = \left(\frac{T_f}{K_m}\right) \times \left(\frac{1}{\alpha}\right) \times \left(\frac{1}{t_{av}}\right) \times K_p = \left(\frac{1000}{1.0}\right) \times \left(\frac{1}{1.0}\right) \times \left(\frac{1}{0.04}\right) \times 1.0 = 25{,}000$$

The calculation results in 25,000 full load working cycles and according to Table 2 to be classified as A3. Please note, the class A3 has the range of: $16{,}000 < C_f \leq 31{,}500$.

Now, the loop conversion from cycle-based classification to time-based classification ($A \rightarrow M$) by applying formula (3.3) is performed. As an input value for the parameter C_f the upper bound of class A3 is considered, therefore $C_f = 31{,}500$. The other parameter values remain unchanged.