VISUAL INSPECTION AND MULTI-TECHNOLOGY ASSESSMENT METHOD FOR ABNORMAL DISPLACEMENT OF HEAVY DUTY OVERHEAD CRANES

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Abstract: This assessment method is based on years of experience in overhead crane visual inspection and analysis. The main concern of the technique is to identify and fix the lateral and diagonal displacement of cranes originating from miscellaneous causes. The assessment method describes the steps to follow when a displacement problem is observed on an overhead crane. The analysis includes runways visual inspection, visual inspection of the runways substructures, visual analysis with cameras, monitoring of the runways substructure and runways displacement with indicators and acquisition system. The method is working by elimination to converge toward the cause of the abnormal displacement. It includes a few techniques of telemetry and traditional precision measurements. The method is in accordance with the ASME[1,2] and CSA[3] standards and with the practices of the industry. On site anecdotes and experiences are presented in conjunction with the applicable standards to provide quick tips to point out a massive amount of interrelated problems.

Key words: Overhead crane, abnormal displacement, inspection, runways, structure, substructure, wear, causes and squareness.

Introduction: Lifting devices in the industrial and commercial facilities are a major concern. For example, in the steel making industry, they often represent the overall limit for a plant enlargement. As a manager and if you are thinking of an eventual expansion of your company you must take in consideration the capacity of your cranes and take an additional security factor for the supporting structure.
Due to the sizes and the lifting capacities of the lifting devices needed in the 2004 industry, small lack of maintenance, inspection and / or information could result in huge problems in lifting devices behaviour. The occurrence of such problems is directly related to operators and workers health and safety.

Overhead cranes are used in all domains of our industry. The metallurgical, pulp and paper, electricity production, manufacturing, freighting and aeronautic industries are dealing with high capacity cranes. We regularly have the opportunity to observe overhead cranes with a capacity over 200 tons. When handling material near the maximum capacity of this type of cranes you have nothing that can insure you that your equipment is in good shape enough to overpass every accident opportunities. Inspection is one of the ways to help the operator and the owner of this equipment to prevent accident occurrences. Personnel training and periodic certification are some other ways to prevent accidents and unpredictable production shutdown.

The objective of this paper is to present the assessment method used by Quebec Levage Expert, a division of X-PER-X inc. to overcome the abnormal displacement of overhead cranes. The method is a step-by-step time saving procedure to limit money expenses when trying to do short interventions during the usual day operations to establish the problem pattern and longer interventions during maintenance nightshifts to perform the inspection and to install acquisition systems. This paper presents five chapters describing every steps of the assessment method. Chapter 2 presents the first step: problem identification. Chapter 3 gives information about the basic measurements to perform, to eliminate the first possible cause of an abnormal displacement, the geometrical and dimensional state of the crane structure. Chapter 4 describes the way to determine the need for a runways alignment. Chapter 5 details the procedure to determine the conformance to the standard of the lateral and vertical deflexion of the overhead runways. And finally, Chapter 6 presents a practical case studied during an intervention at a client facility.

Results:

CHAPTER 2: PROBLEM IDENTIFICATION

Information gathering begins by interviewing the plant manager, the crane operator and the maintenance mechanics. It is very important to gather all the information these persons can provide because they probably have important clues for the main cause or causes of the abnormal displacement. Generally, the operators who work on a heavy service overhead crane have a good knowledge of its behaviour mainly because they perform up to 500 load cycles per shift. With this kind of perspective it is easy to understand why it's important to make good connexion with the operators, to gather every pieces of the puzzle.

Visual observation of the crane from the plant floor will also help to locate critical zones of the runways where clues could be found. With only an hour of observation, it is relatively easy to see if inappropriate working habits exist or if there is a zone where the crane is used more often. This information could lead to the determination of a tendency of crane translation displacement during the regular operation or a movement pattern of the lifted load that could have an effect on the structure.

Another possibility could also be considered. It consists in assisting the operator inside the cabin during his operations. The latest, imply a complete cooperation of the company staff and union. From this point of view, it is much more easy to see and feel the crane movements. When there is an abnormal displacement of the crane, sudden movement or vibration of the crane could be observe. Because of the location of the cabin that is generally between both main girders, the operator has the opportunity to see at least one end-truck, both girders, the lifted load and the runways substructure who act as a static reference. Knowledge of the maintenance mechanics cannot be discarded. They usually remember when they have replaced a part and how often they did it during the past years. They also have an idea about the frequencies of the timing verification of the driving wheels motor, brake adjustment, wheel replacement, parts lubrication, etc.

CHAPTER 3: DIMENSIONNAL ANALYSIS

3.1 Driving and slave wheels diameter

Driving wheels diameter can be a major contributor to the abnormal displacement of an overhead crane. Difference in diameter should result in a lateral displacement toward the side of the smaller driving wheel. After a certain distance depending on the difference in diameters, the interior flange of the smaller driving wheel receives an important amount of lateral stress. This stress can be high enough to cause the failure of the flange. In general, the only phenomenon observed in this particular situation is a premature wear of the lateral stressed face of the runways. When both runways are compared, the worn faces are located on the same side.

CMAA[4] Specification #70 states that the driving wheels should be match by pairs within 0,001'' per inch of diameter for a total maximum of 0,010'' whichever is smaller. For example, a difference 0,060'' between both driving wheels with a 30 inches diameter of an overhead crane, represents an advance of 0,600'' when the larger wheel has rolled over 25 feet of runway. The theoretical advance at the end of a 400 feet runway is 9,600 inches. In a more practical approach, this difference is lower at the end of the runways. The small successive movements forward and backward of the crane, helped by the lateral forces applied by the runways on the flanges of the crane wheels, tends to realign the crane on the runways.

3.2 Overhead crane squareness

Squareness and parallelism of the wheels of an overhead crane could affect significantly its behaviour during longitudinal displacement. In theory, this technique is very simple. It consists in measuring both diagonals of the crane and comparing the two measures. The difference has to be lower than 0,250 inch on a 100 feet diagonal length.

On the field, the difficulty is related to physical space. Because of the great distances that have to be measured, the use of a measuring tape is unpractical. In this case, optical telemetry is the most appropriate technique. Because of the location of the crane that is generally built near the building trusts, the use of a set-up to take measurements over the crane is impractical too. The easiest and precise way of measuring both diagonals of a crane is to trace back the reference point on a set-up placed near the wheels and attached to the runways. The reference points could be the axle of the corner wheels in the case of a 4 wheels crane or at the equalizing axles of 8 to 16 wheels crane (Figure No 1).

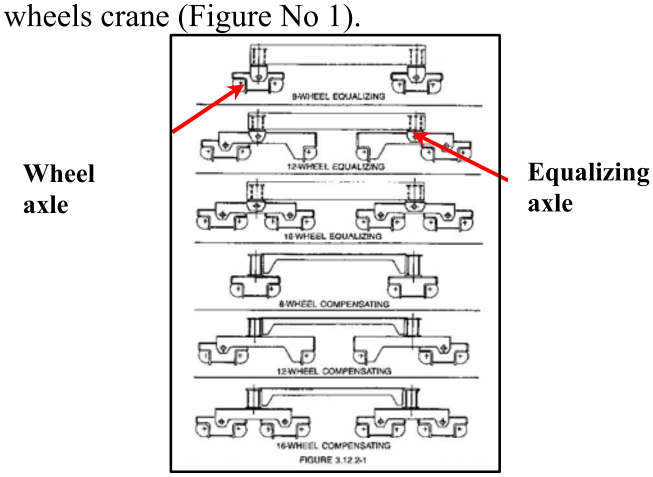


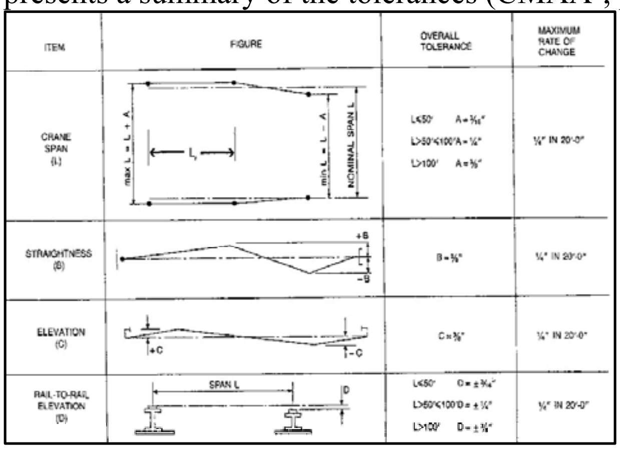
Figure No 1: Different types of end-trucks and positions of wheel axles and equalizing axles

Once traced back to the set-up attached to the runways and the crane moved apart, the diagonals can be measured. During this operation it is recommended to measure the span between the end-trucks and the span between the wheels of one end-truck too. These measurements can be useful for future calculations.

CHAPTER 4: RUNWAYS ALIGNMENT

The need for a runway alignment can be evaluated by many means. In the most obvious cases, the most qualitative technique is to do a visual evaluation from one end of the runway. The technique we recommend is more precise and appropriate when we take in consideration the amount of money that is related to runways realignment. The most accurate method uses cameras and an encoder that is encoding on time. The encoder gives the exact correspondence of the crane position vs time during the inspection and the cameras linked to a video multiplexer gives all the necessary visual information vs time. These data coupled together present an image at a precise time during the operation and at a precise place on the runway. In a continuous process, we could also do a cross-reference with the data of the process itself (temperature, batch No, etc.). With the cameras, it is possible to evaluate the variation of distance between the runway and the two flanges of the wheels of the cranes. This information allows the specialist to determine the possible problematic zones.

CMAA[4] Specification #70 states that the maximum rate of distance variation between both runways is 0,250'' in 20 feet or an overall maximum of 0,375'' when the span is over 100 feet. When only one runway is considered, the straightness tolerance is ± 0,375'' with a maximum variation of 0,250'' in 20 feet. The table in Figure No 2 presents a summary of the tolerances (CMAA[4], page 7).



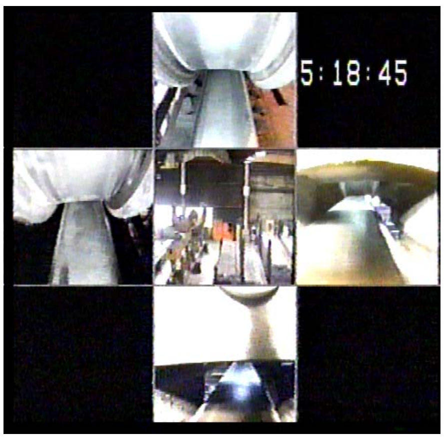
ITEM	FIGURE	OVERALL TOLERANCE	MAXIMUM RATE OF CHANGE
CRANE SPAN (L)	max L = L + A; L_1; min L = L − A; NOMINAL SPAN L	L≤50' A = 3/16" L>50'≤100' A = 1/4" L>100' A = 3/8"	1/4" IN 20'-0"
STRAIGHTNESS (B)	+B; −B	B = 3/8"	1/4" IN 20'-0"
ELEVATION (C)	+C; −C	C = 3/8"	1/4" IN 20'-0"
RAIL-TO-RAIL ELEVATION (D)	SPAN L; D	L≤50' D = ±3/16" L>50'≤100' D = ±1/4" L>100' D = ±3/8"	1/4" IN 20'-0"

Figure No 2: Straightness tolerances specified in CMAA[4]

Cameras installation on the crane has to be perform during maintenance and shutdown periods. They are placed in a certain way to observe the contact surface of the wheel, the rail and both flanges of the wheel. With this view, we are able to evaluate the distance from the flange to the side face of the rail and have an idea where a lateral force is applied on the rail. This information will help us in the next section to establish the location of a highly stressed region.

At every corner wheel, a camera is installed (Picture No 1). A supplementary camera is also installed on the crane to record a general view presenting all the movements of the lifted load (centre view, Picture No 2). The cameras are coupled to a video multiplexer to recuperate all the signals and present it on the same screen. With this electronic device, the analysis of the movements of the crane is more simple and allow the specialist to compare the position of each wheels and being aware of the operation performed by the crane operator. Picture No 2 presents an example of the type of information recorded during an analysis.

Picture No 1: Position of a video camera behind a slave wheel



Picture No 2: Image recorded with the video multiplexer and a digital recorder

After the visualisation of the video sequence, a decision regarding the need for more precise study performed by a land surveyor is taken. Usually, when the driving wheel diameters are within the tolerances, when the squareness of the crane meets the standards specification and when deviations of the runways are observed during the visual inspection, a chaining of the runways has to be performed.

CHAPTER 5: DEFLECTION OF SUBSTRUCTURE

When the runways substructure is suspected, the easiest way to bypass engineering study on the supporting structure is to verify that all deflections meets the standards specifications. To be able to perform these measurements during the usual crane operations and respect the health and safety legislations of the company you must use a remote controlled acquisition system. To realize this analysis, digital indicators are placed in the zone where the appearing lateral force seemed to be the highest. This or these zone(s) should has (have) been pointed out during the visual inspection with cameras. Indicators are positioned at the half span of the runway-supporting beam. To determine the maximum lateral deflection, an indicator is placed horizontally at the top and at the bottom of the web. For the vertical deflection, the indicator is placed under the beam in a vertical direction to touch the lower flange directly under the web. Picture No 2 presents the set-up used during an analysis and Figure No 3 presents the measurements recorded by the acquisition system.

Picture No 2: Set-up for digital indicators installation

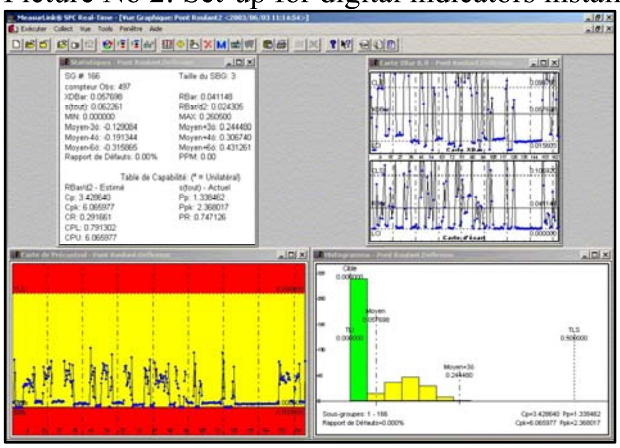


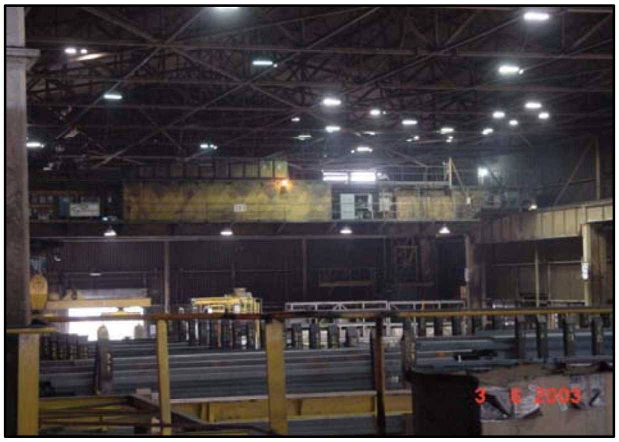
Figure No 3: Results out coming from the digital indicators and recorded by the acquisition system

During the data compilation, the most important values are the highest lateral deflection and the highest vertical deflection. These values have to be under a ratio of Lr/400 for the lateral deflection and Lr/600 for the vertical deflection. The constant Lr represents the length of the span between both principal girders of the overhead crane. This span usually corresponds to the distance between the two wheel axles of the same runway, or if there is more than four wheels, it represents the distance between both equalizing axles.

Discussion:

CHAPTER 6: PRACTICAL CASE

A 22 tons heavy service overhead crane (Picture No 3) had experienced many problems in the past years. There are few important facts about this particular case. Cracks were found on the top of the columns of the runways substructure. Failure of a flange on one main wheel was also reported. Many guide wheels bearing were replaced over the years at a rate of 4 to 5 per year. An operator reported regular vibration of the crane. The engineering department suspected building foundation and building design. Preferential wear of the runways was observed on the South face of the rails. Replacement of driving wheels was done one by one.



Picture No 3: 22 tons heavy service overhead crane

Following our preliminary observations, no displacement pattern was operating. The lateral displacement of the crane seemed to be hazardous. An operator of the crane mentioned that after a run of about 100 feet, the crane was shifting laterally by small strokes. The engineering department reported a displacement of the runway of approximately 0,500 inch at a precise point of the North runway. According to our measurements, the driving wheels diameters were different. The replacement of the driving wheels was done one wheel at the time and this has led to a 0,060-inch difference in driving wheel diameters. The squareness of the crane was within the standard specifications.

The zone where a lateral displacement of the runway was reported has been monitored with digital indicators to verify that the lateral deflection was within the standard specifications. The vertical and lateral deflection met the standards specifications.

Visual inspection with cameras revealed multiple lateral movements of the overhead crane in both directions and a tendency to apply a lateral force on the South face of the runways rail. This was the explanation for the premature wear observed and for the periodic replacement of guide wheels.

Conclusions:

This practical and step-by-step assessment method for abnormal displacement of overhead cranes was built according to the experience of Quebec Levage Expert engineers and technicians, to the industry practices and the applicable standards. Our experience in this particular domain revealed that without any planning or assessment method, it is easy to loose time and money to solve a displacement problem of an overhead crane. Although, the method is standard and may be modified to fulfil the special needs of every systems and customers.

About our practical case, our investigation revealed that the driving wheels should be replaced by pair and that a runways chaining should be perform to determine the theoretical position of the rails and prepare the maintenance department for a rail realignment session. These two recommendations allowed to correct the abnormal displacement.

References:

1. ASME B30.2, Overhead and gantry cranes, (1996).

2. ASME B30.20, Under the hook lifting devices, (1996).
3. CSA B167, Overhead electric cranes for general purpose, (1964).
4. CMAA Specification #70, Crane Manufacturers Association of America, (2000).