Boosted Productivity and Efficiency for Structural Inspections

Overview

- TSM C&S Consultants PTE. LTD. wanted to streamline their workflow with multiple inspections happening simultaneously
- Screening Eagle INSPECT was identified as a solution to save time, store, consolidate and share their data
- They increased productivity but at least 40%, saved time, and used less manpower on inspections.

TSM is a civil and structural engineering consultancy company in Singapore providing design, inspection, and project management services to local government agencies and various private sector clients, including the Singapore Pool Head Quarters, Former Thong Chai Medical Institution, inspection for over 100 of electrical substations for Singapore Power, the project of Oxley Bizhub building inspection and the inspection at the largest airport in South-east Asia.

The Challenge

Typically, many inspection projects are conducted simultaneously, and each project requires certain manpower and a lot of data collection, including taking dozens of photographs. For TSM, it was time-consuming to manage the data collection, sorting, storage and sharing with the many stakeholders. For example, the report preparation alone can take more than a day. Another major challenge during inspections is communications among inspectors, engineers, building owners, consultants, and contractors.

The Solution

TSM identified the cloud storage based 'Screening Eagle INSPECT' app as a solution to their challenges. From the iPad app, TSM set up and managed projects, took high-resolution photos, tagged them by location, located the crack/defects by artificial intelligence (AI), generated reports in seconds on-site and shared them with all stakeholders.

The INSPECT web application provided additional functions to the iPad App, from where TSM could manage the accounts and customize inspection workflows and report structures. This made it easy and simple to communicate seamlessly both in the intuitive iPad App and the powerful web App.

Introduction

Conversion curves are one of the indispensable elements in the field of hardness measurement. Many users are familiar with the Brinell, Vickers, Rockwell, or Leeb scales and use conversion curves in their work every day. However, few users know how they are generated and how to use them properly. This article shares exactly what conversion curves are, how they are developed and how to use them properly.

Highlights

- Conversion curves are purely empiric and specific for each material group. Conversion curves are mathematic functions (equations) created based on conversion tables.
- No equation would convert ideally one hardness value to another hardness scale.
- Conversion curves give a close approximation of a measurement expressed in other, non-native units, under the condition that the material used to generate the curves is the same as the material to which the curves are applied. They are material-specific.
- Conversion introduces additional uncertainty to the measurement
- Whenever possible, use the native scale to avoid introducing additional uncertainty

Why do users want to convert?

Working with different hardness test methods often requires the hardness measured by one method to be converted to that for another method or strength (tensile strength in N/mm²). If a measured hardness value is meant to be converted into another scale (i.e. into the result of a completely different hardness testing method), there is no mathematical equation for doing this.

Generally, there are no applicable relations for converting hardness values from one method to another. However, so-called conversion tables, determined through experiments and measurements, enable easy conversion of scales.

How are conversion curves generated?

To generate a conversion curve, the hardness of several up to few dozens of specimens with varying hardness values is measured using the different test methods. The relation between the individual scales is then established. Such conversions can only be carried out if a sufficient number of comparison measurements has statistically safeguarded the conversion relation. For example, the following table (Table 1) represents the n samples, whereby each of them has different hardness values but is made out of the same material. Those specimens are then tested with various methods (here, exemplarily, these methods are denoted as A, B, C and D) and allow for the establishment of the conversion table.

For example, $Hx1.4_A$ (a sample with 40% higher hardness than the first population member, measured with method A) would be then expressed in another scale measured by method C as » $Hx1.4_C$.

These tables are then converted to mathematical equations, which enable a smooth conversion of the intermediate hardness values (for example sample with hardness x+5.43% could be computed on the basis of such an equation to $Hx1.0543_B$) because the relationship between numerous samples could be mathematically described as conversion curve.

The same procedure is then applied to other material classes to establish other relationships between the hardness values of different test methods.

The challenge of the conversion curves

As indicated above, the conversion curves are always close approximations. The users very often are unaware that their conversion is an approximation and blindly believe that the end results after conversion are equal to the hardness value expressed by another hardness scale unit.

Because of the necessary experimental determination of the conversion curves for different materials, errors should be taken into account here. There will be a corresponding, additional factor of uncertainty when converting into another scale. Another key point to take into account is that many materials have different hardness based on different microstructure, processing conditions and perhaps some minor yet contributing variations in chemical composition. Although the conversion tables specify the chemical compositions of various steels, variations in chemical compositions occur, and the subsequent processing may induce other changes to the materials.

Portable testing methods offer the inspectors and users freedom and significantly simplify the testing procedure. They can be carried out on the spot and in a non-destructive manner, instead of the laborious procedure of cutting out, transporting, and measuring with the bench-top method (e.g. Brinell or Vickers) followed by microscopic analysis of the indent. However, they do impose additional measurement uncertainty as they all are, to some extent user-dependant, which means: additional uncertainty to consider.

How can a company overcome all or at least some conversion limitations?

Luckily the most important mitigation is to make users aware of the limitations. In addition, if you have a production line and process various or non-standard materials, try to establish your own conversion curve on the basis of your own materials, keeping in mind all best practices for sample preparation (weight, wall thickness, surface roughness, statistics). Equotip, besides the **broadest conversion curve portfolio on the market**, offers various ways of generating conversion curves, starting from a simple but range-limited one point shifts, two-point approximations and the best and most accurate **multipoint conversion curves**, where the user can efficiently compute and simply implement its own conversion curve on the basis of few samples into the [Equotip 550 devices.](#)

In other words: A material defined in the conversion tables must not be exactly the same material that the end-user is trying to measure. This is especially important for materials that undergo many processing steps.

What would be the best practice?

If you are using a [portable testing method](#), e.g. Leeb and if this is possible for you to switch entirely to that method, try adopting a native scale (e.g. HLD) across the entire production chain. By doing so, you are not only simplifying the quality assurance process but avoiding the contribution of unnecessary uncertainty that comes from the empiric nature of conversion curves.

It is always recommended to use the native scale of the test method and always keep in mind that the conversion of hardness values is an approximation.

If you are using a simple one-point shift correction, keep in mind that this material-specific correction shall be applicable for the hardness measured within the vicinity of the measured test piece. In other words: One shall not define a one-point shift for soft materials and use same conversion for very hard ones.

Suppose you consider the application of Ultrasonic Contact Impedance (UCI) method. In that case, you must always keep in mind that this technique is designed for the steel with Young's modulus (E) of 210 GPa, and any material with a different E value will show erroneous readouts. Try employing a portable Rockwell, that measured an indentation depth and is material-independent.

Schematic illustration of a conversion table

	Test method A	Test method B	Test method C	Test method D
Sample with hardness x	Hx_A	Hx_B	Hx_C	Hx_D
Sample with hardness x + 10%	$Hx1.1_A$	$Hx1.1_B$	$Hx1.1_C$	$Hx1.1_D$
Sample with hardness x + 20%	$Hx1.2_A$	$Hx1.2_B$	$Hx1.2_C$	$Hx1.2_D$
Sample with hardness x +30%	$Hx1.3_A$	$Hx1.3_B$	$Hx1.3_C$	$Hx1.3_D$
Sample with hardness x +40%	$Hx1.4_A$	$Hx1.4_B$	$Hx1.4_C$	$Hx1.4_D$
…	…	…	…	…
Sample with hardness x +n%	Hxn_A	Hxn_B	Hxn_C	Hxn_D

Table 1. Schematic representation of a hardness conversion method. Important to highlight that the specimens and measuring
conditions for these tests are nearly ideal: low surface roughness, size and dimensions correspond to standard requirements, appropriate statistics is applied together with adequate number of measurements. Often the tables are generated through a so called Round-Robin method, that means that several parties carry out same measurement under same conditions to confirm the correctness of the method.