ADVANCES IN SELF-TAPPING WOOD SCREWS

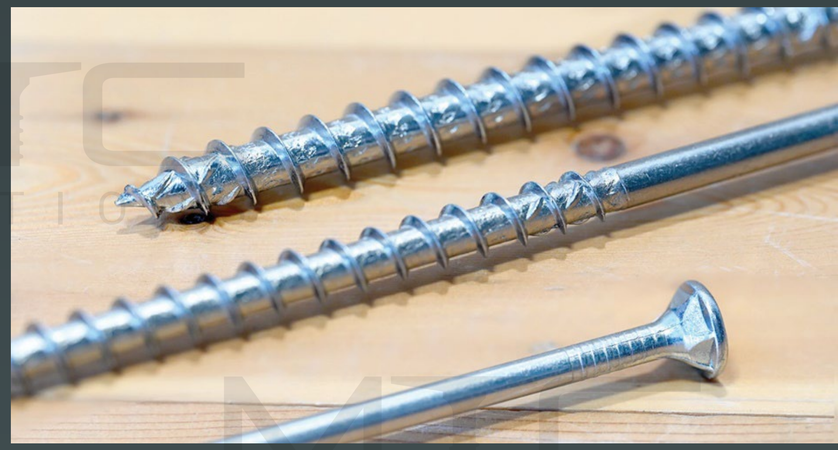
Navigating New Standards and Mitigating Hydrogen Embrittlement

MTC SOLUTIONS

MTC SOLUTIONS

MASS TIMBER HARDWARE

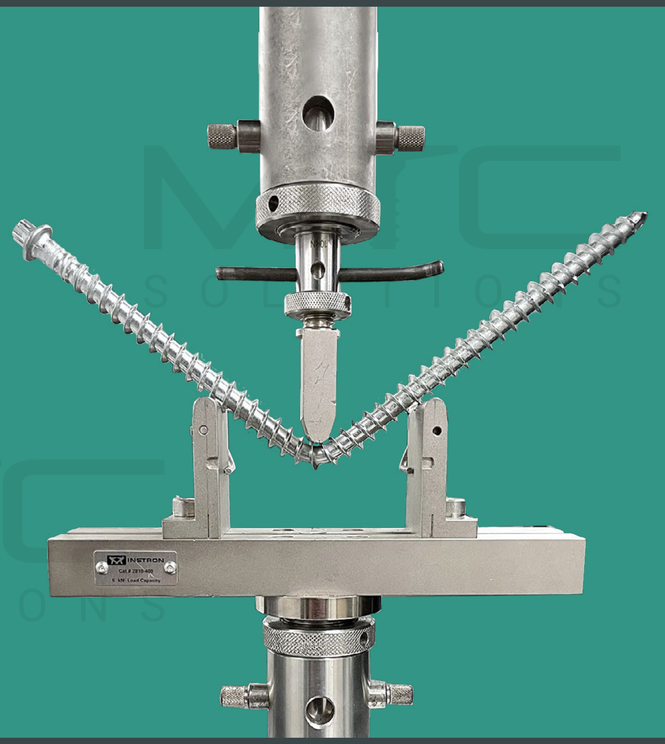
by engineers, for engineers

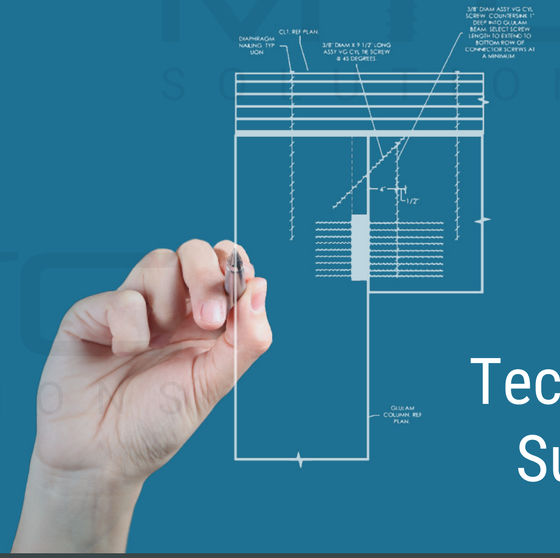


Being the Recognized Expert

Code Approved Products

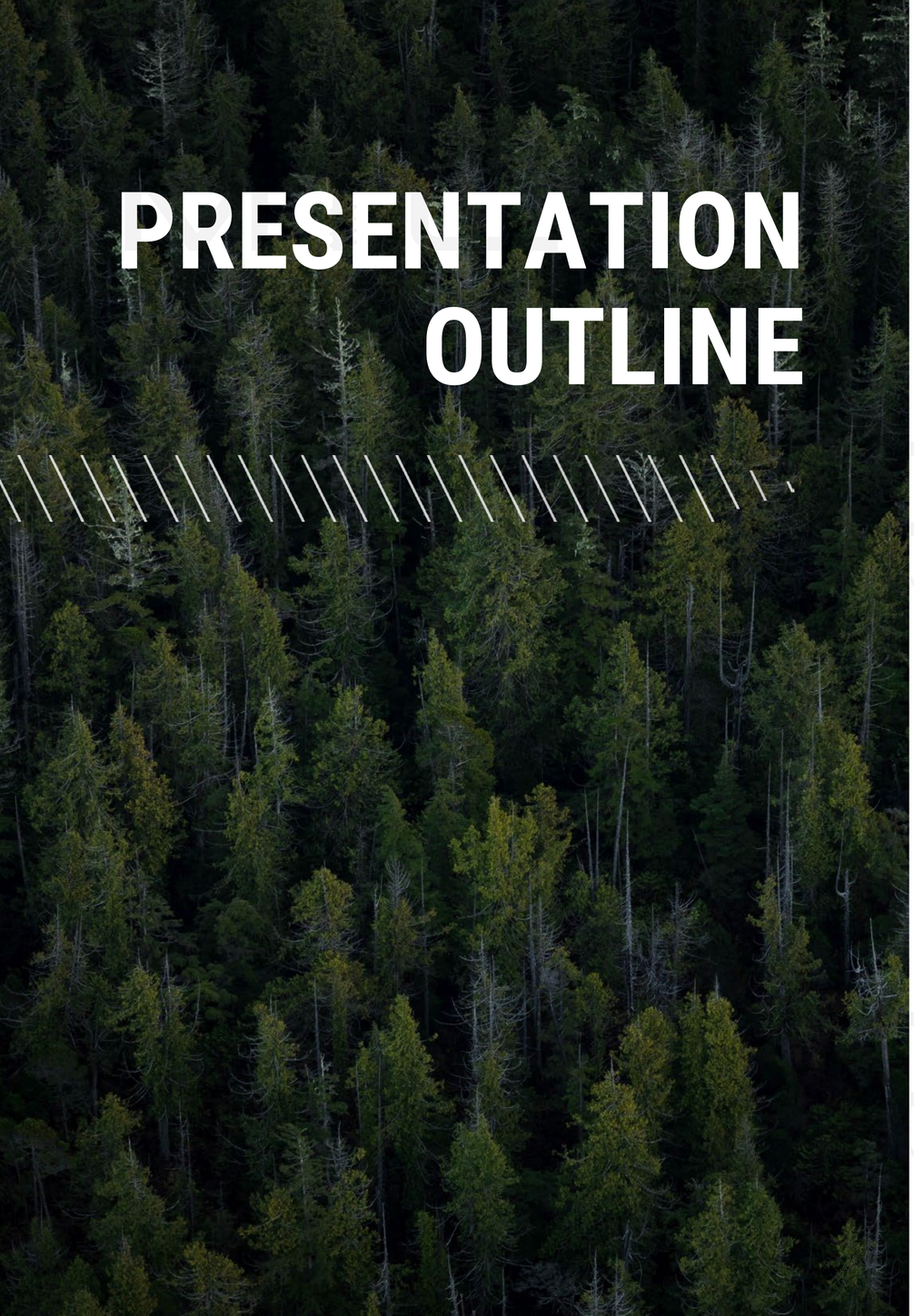
Tested Solutions





Technical Support

Detailed Design Guides



PRESENTATION OUTLINE

NEW! CSA O86:24 Updates

- Chapter 12.12 Self-Tapping Screws
- Chapter 17.6 Self-Tapping Screws

Hydrogen Embrittlement (HE)

- What is HE?
- The effect on Mass Timber

MTC Quality Control

How to Specify

CSA-O86 UPDATES

CSA O86:24

12.12 Self-Tapping Screws

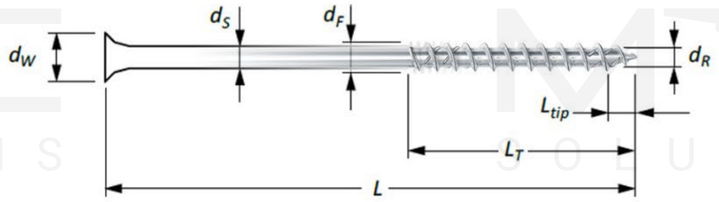
From many resources...

..to one centralized chapter

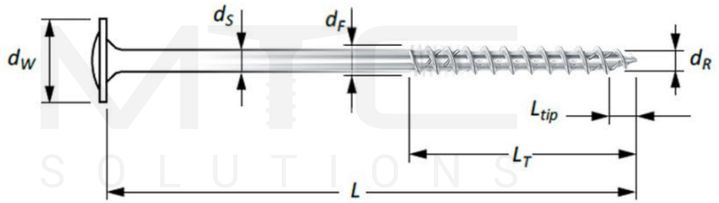
CSA GROUP™

O86:24

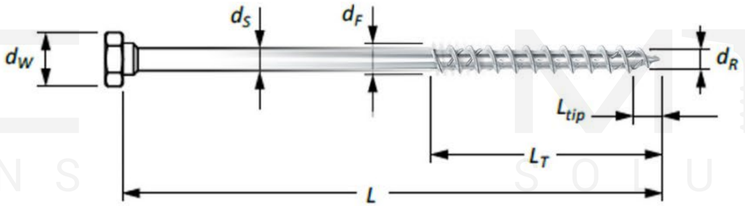
a) Partially threaded screw with countersunk head



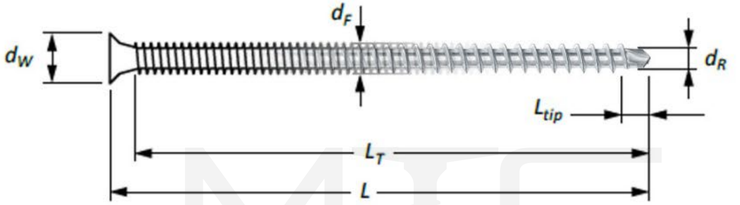
b) Partially threaded screw with washer head



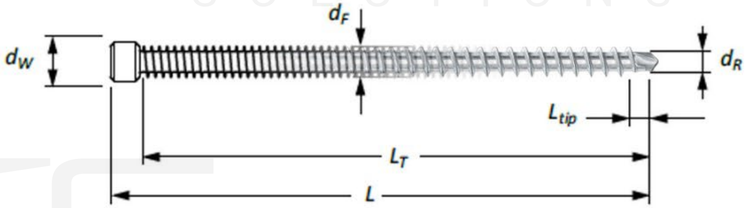
c) Partially threaded screw with hexagonal head



d) Fully threaded screw with countersunk head



e) Fully threaded screw with cylinder head



CSA O86:24

12.2.1.7 Modification Factors

Carbon steel screws with a maximum core hardness above 36 HRC (360 HV) shall not be used in wet-service conditions.

The value of K_{SF} for this condition shall be in accordance with the supplier's product evaluation report.

Note: *See the CWC Commentary on CSA O86 for further information on connection details.*

– CSA O86:24 12.2.1.7

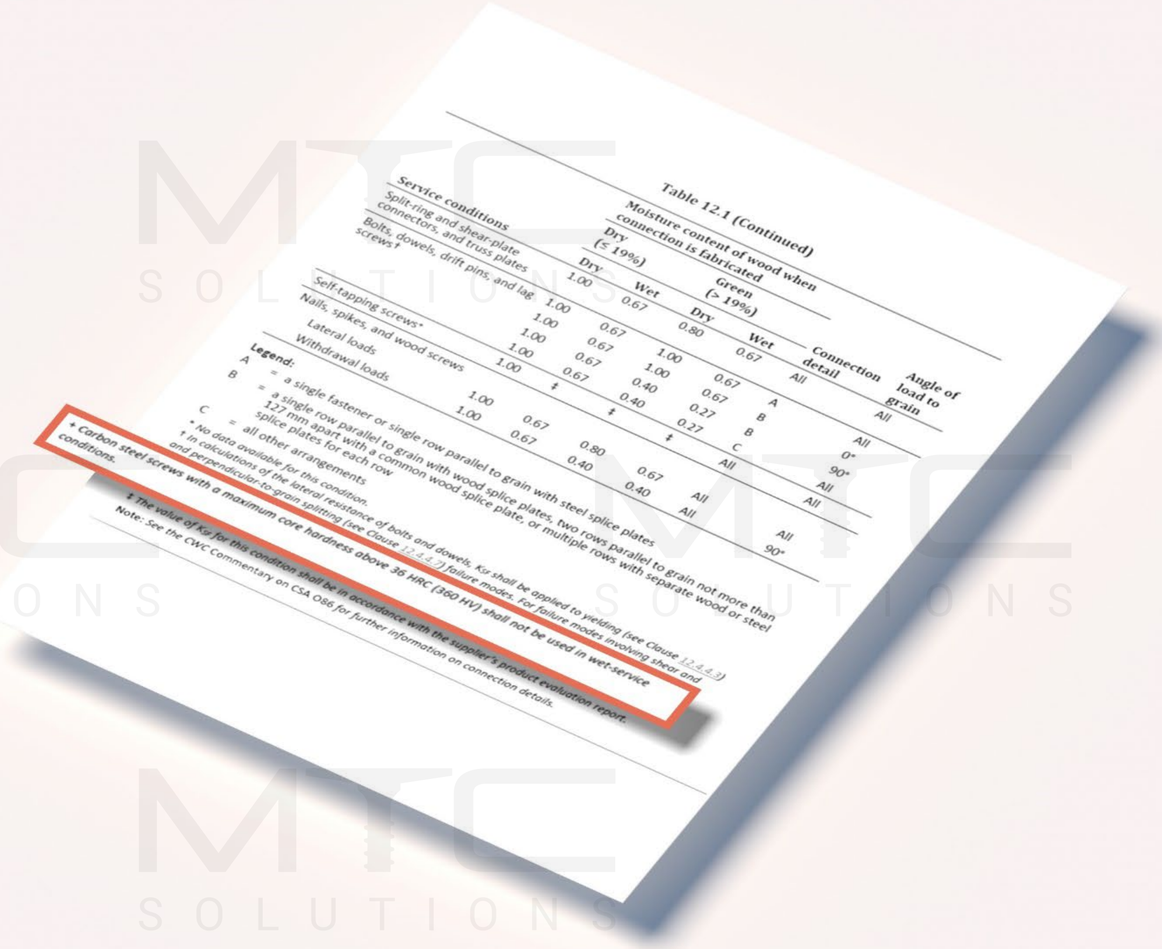


Table 12.1 (Continued)

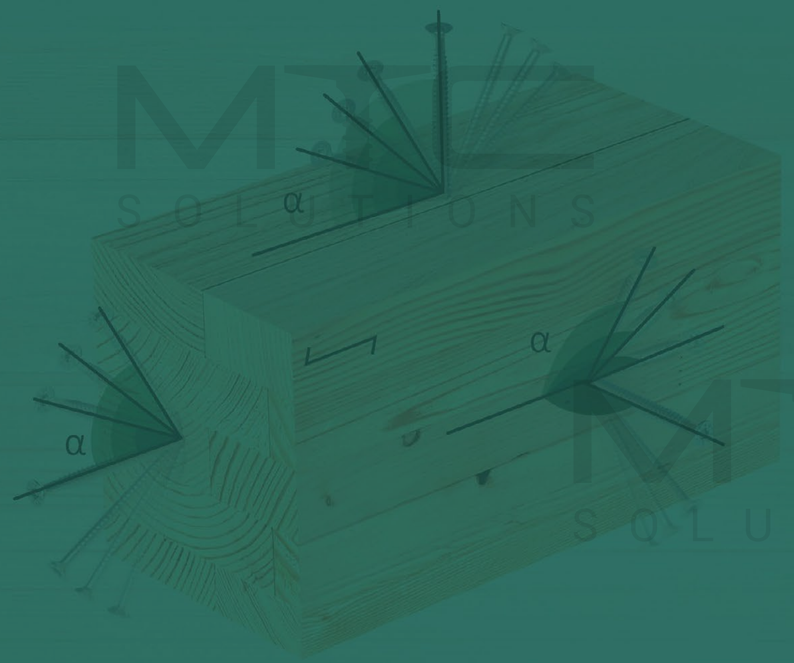
Service conditions	Moisture content of wood when connection is fabricated				Connection detail	Angle of load to grain
	Dry (≤ 19%)		Green (> 19%)			
	Dry	Wet	Dry	Wet		
Split-ring and shear-plate connectors, and truss plates	1.00	0.67	0.80	0.67	A	All
Bolts, dowels, drift pins, and lag screws†	1.00	0.67	1.00	0.67	B	All
Self-tapping screws*	1.00	0.67	1.00	0.67	C	0°
Nails, spikes, and wood screws	1.00	‡	0.40	0.27	B	90°
Lateral loads	1.00	0.67	0.80	0.40	All	All
Withdrawal loads	1.00	0.67	0.80	0.40	All	All

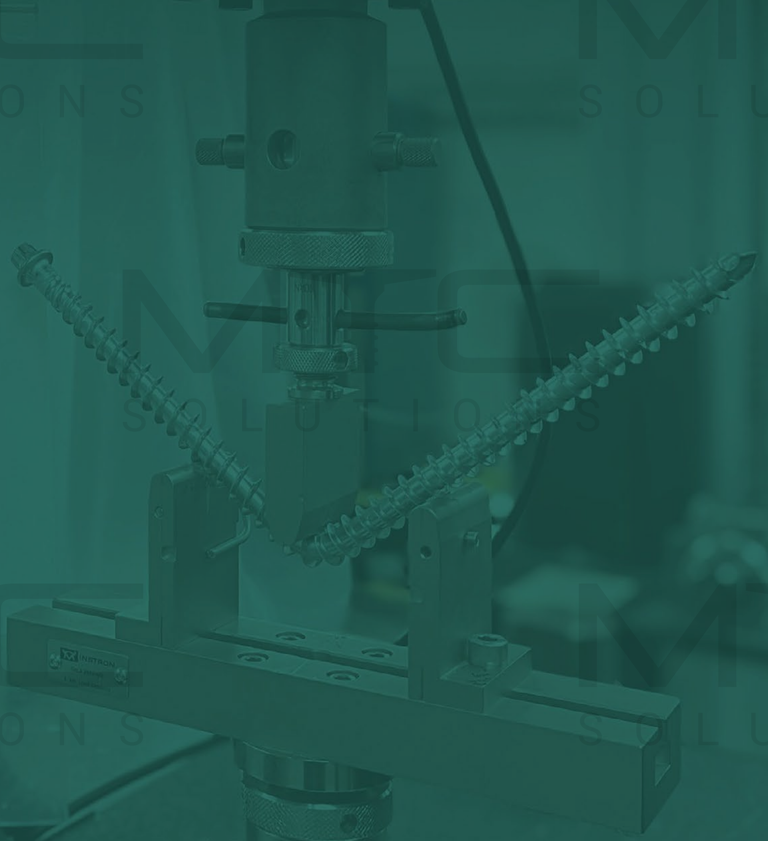
Legend:
A = a single fastener or single row parallel to grain with steel splice plates
B = a single row parallel to grain with wood splice plates, two rows parallel to grain not more than 127 mm apart with a common wood splice plate, or multiple rows with separate wood or steel splice plates for each row
C = all other arrangements

* No data available for this condition.
† In calculation of the lateral resistance of bolts and dowels, K_{SF} shall be applied to yielding (see Clause 12.4.4.3) and perpendicular-to-grain splitting (see Clause 12.4.4.7) failure modes. For failure modes involving shear and conditions.
‡ The value of K_{SF} for this condition shall be in accordance with the supplier's product evaluation report.
Note: See the CWC Commentary on CSA O86 for further information on connection details.

BRAND NEW CHAPTER!

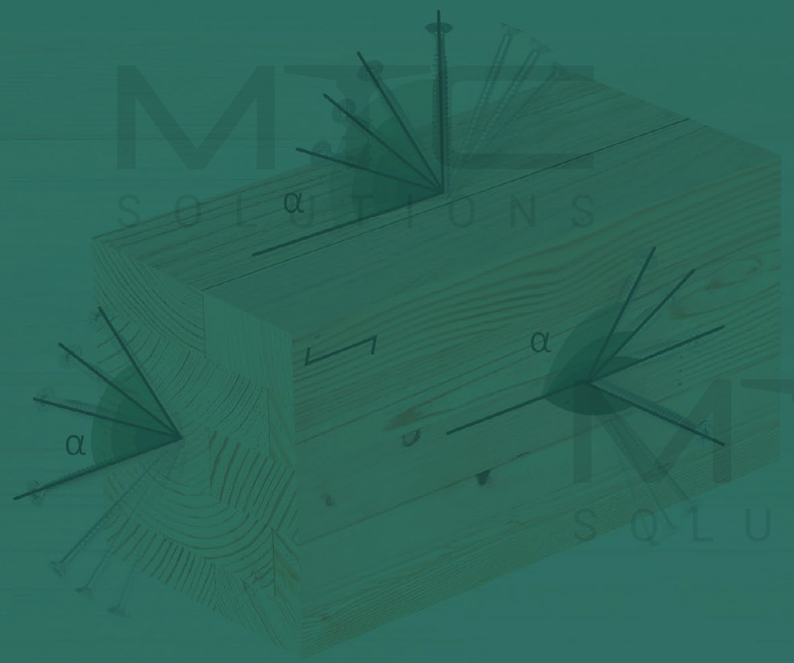
17.6 – Materials and Evaluation: Self-Tapping Screws





17.6 – Materials and Evaluation: Self-Tapping Screws

SCREW PERFORMANCE PROPERTIES



MECHANICAL TESTING

HYDROGEN EMBRITTLEMENT CONCERNS

17.6.4: Hydrogen Embrittlement

- Hardness limits
  - 360 HV < x < 390 HV
- IHE: a manufacturer's problem
- EHE: an installer's problem
- QC: an MTC engagement

Case-hardened carbon steel self-tapping screws shall meet the following requirements:

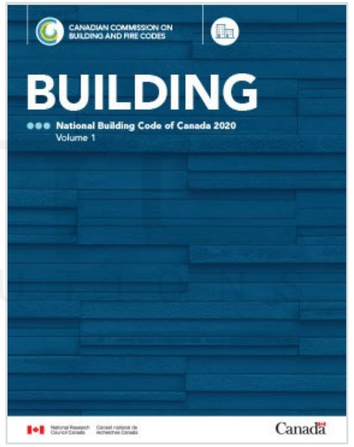
a) The maximum core hardness shall not be greater than 38 Rockwell C (HRC) for screws produced in accordance with ASME B18.6.3 or 390 HV for screws produced in accordance with ISO 2702.

b) Electroplated screws with a maximum core hardness greater than 36 HRC (360 HV) and less than or equal to 38 HRC (390 HV) shall satisfy the requirements of the internal hydrogen embrittlement (IHE) test in accordance with ASTM F606 Clause 7 or ISO 15330 as part of the manufacturer's quality control assurance plan.

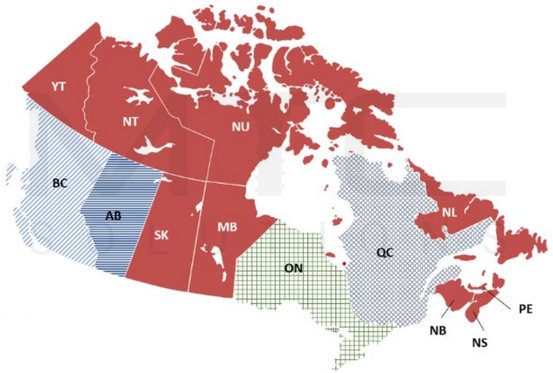
CSA O86:24

17.6 Self-Tapping Screws

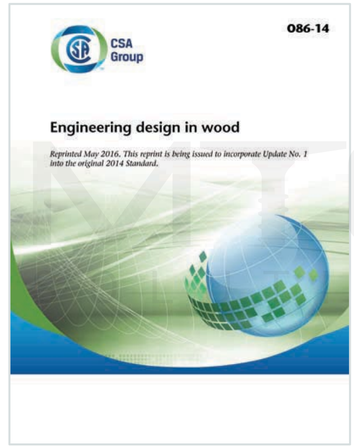
- While the CSA O86:24 is not yet mandatory under design codes, it will be soon
- Ignoring HE risk would be an ethical concern given this update and the fact that HE is not a new failure mechanism



NBC: **2020**



ABC: **2023**
BCBC: **2018**
OBC: **2012**
QBC: **2015**

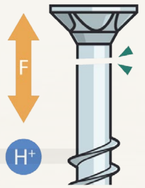


CSA O86: **2024**

HYDROGEN EMBRITTLEMENT

WHAT IS HYDROGEN EMBRITTLEMENT?

HE is:



A permanent loss of ductility in metal due to **hydrogen** in combination with **stress**

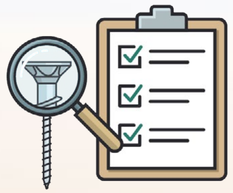
A **delayed** failure that may happen minutes, hours, or years after installation

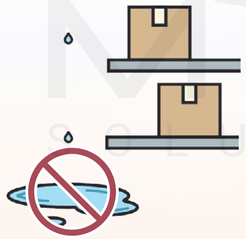
HE is **NOT**:

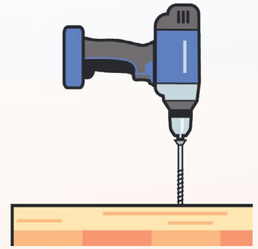
Failure **during** installation (drill engaged), which is an **over-torquing** failure

HYDROGEN EMBRITTLEMENT

A Shared Responsibility







Quality Control → **Transport** → **Onsite Storage** → **Installation**

Manufacturer's Priority

? ? ?

? ? ?

Installer's Priority

HYDROGEN EMBRITTLEMENT

What is HE?

Hydrogen atom

Grain boundary

Tensile stress

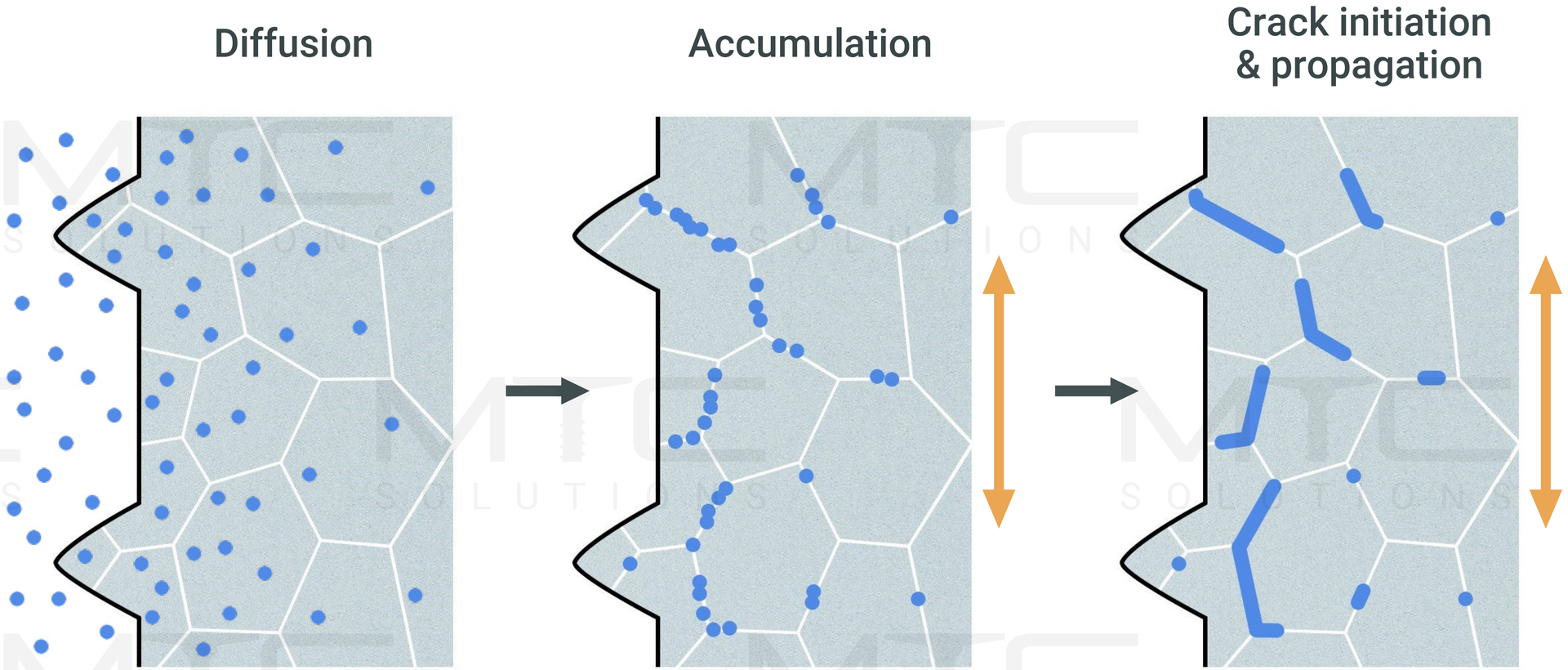
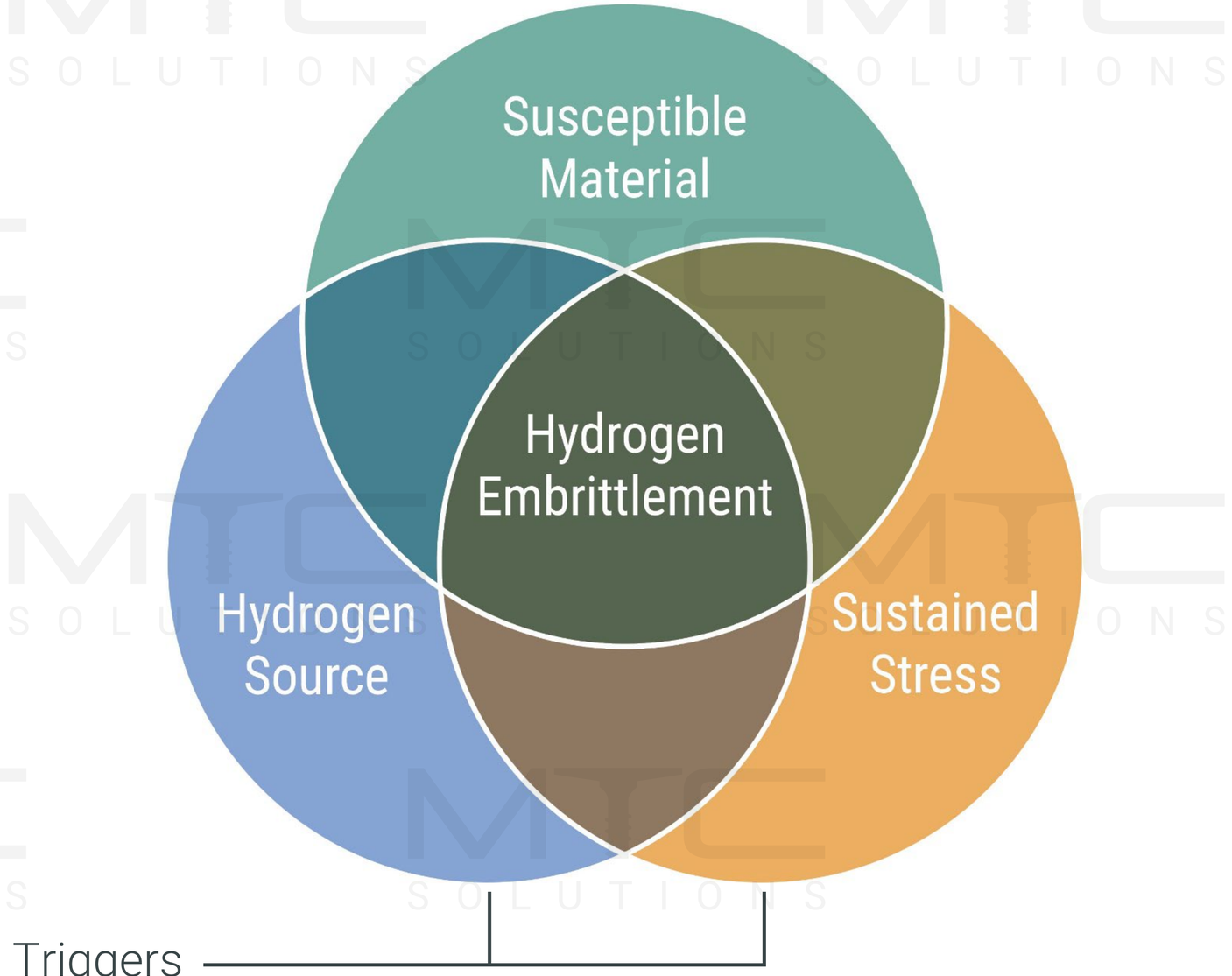


*illustration not to scale

HYDROGEN EMBRITTLEMENT

What is HE?

What factors influence the occurrence of hydrogen-induced brittle fractures?



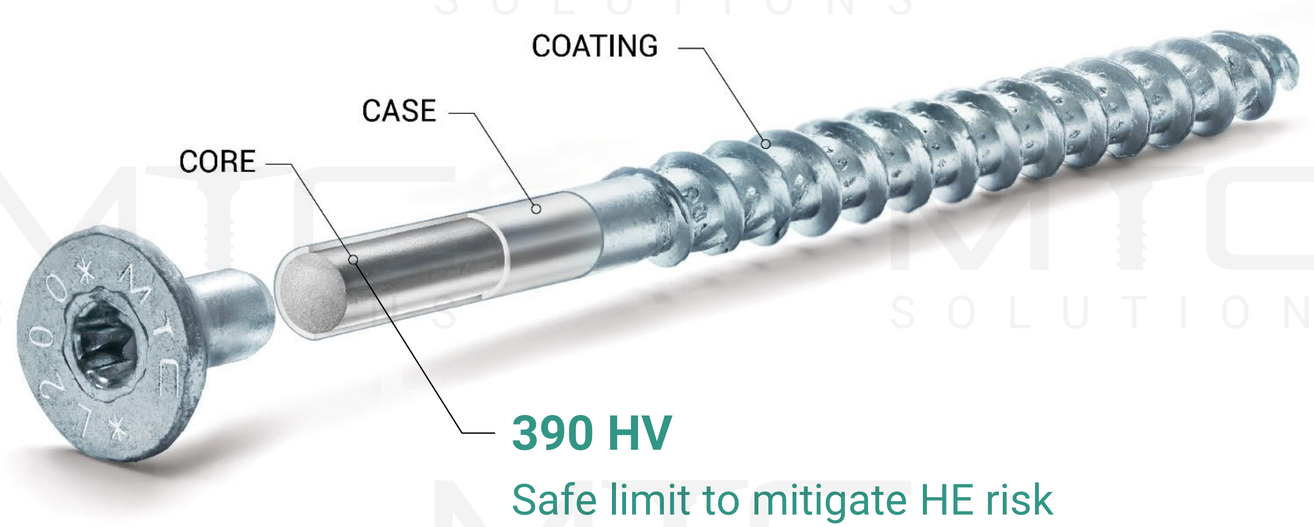
HYDROGEN EMBRITTLEMENT

HE and Self-Tapping Screws

All **mass timber screws** made from carbon steel generally fall in the range of **360 HV to 390 HV**.

Note: Not suitable for wet service conditions.

Defining Property: Core Hardness



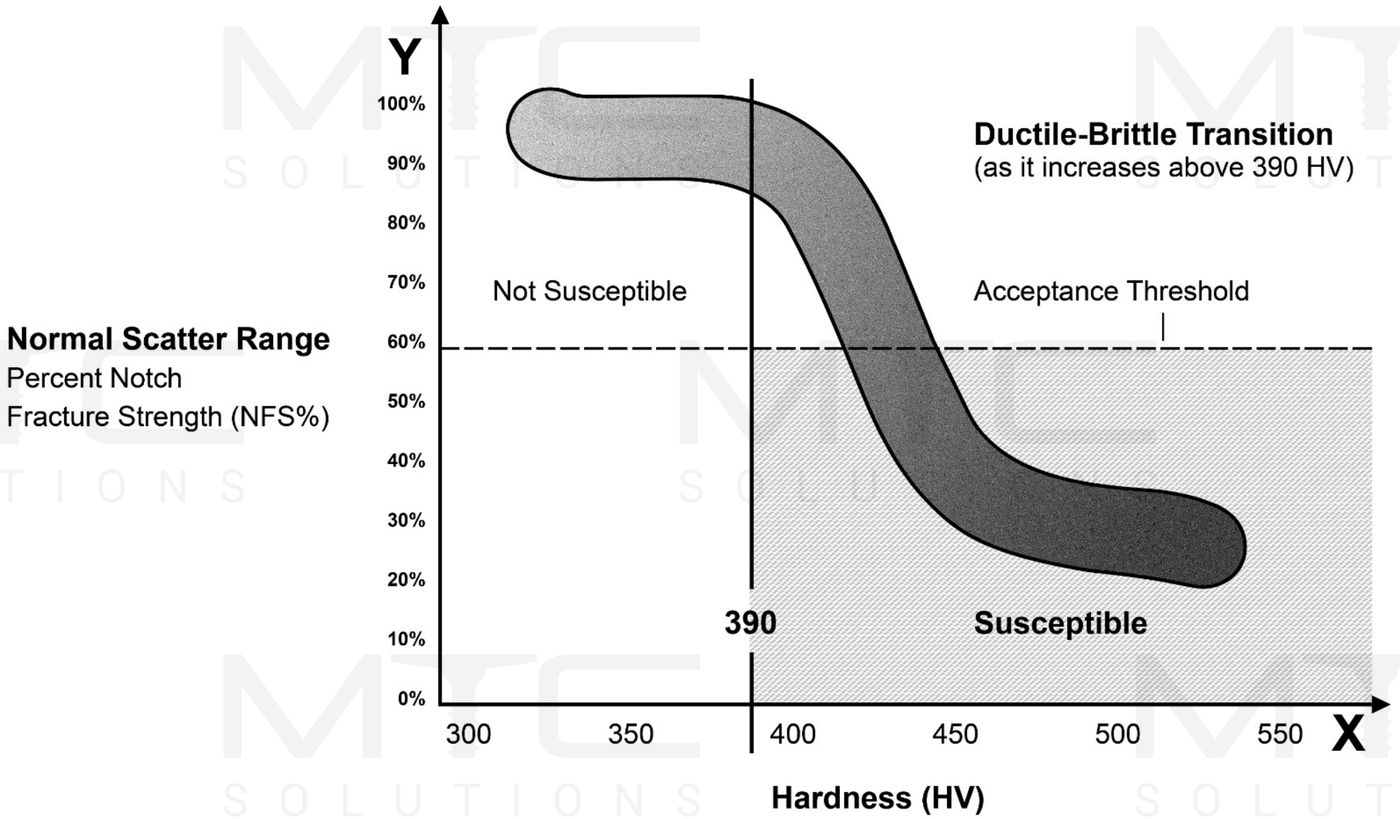
390 HV

Safe limit to mitigate HE risk

HYDROGEN EMBRITTLEMENT

HE Susceptibility

Range of HE Threshold Stress Curve



Source: ISO/TR 20491:2019

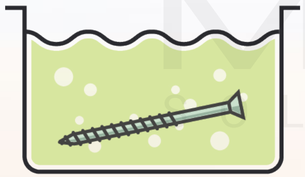
Internal Hydrogen Embrittlement (IHE) VS Environmental Hydrogen Embrittlement (EHE)

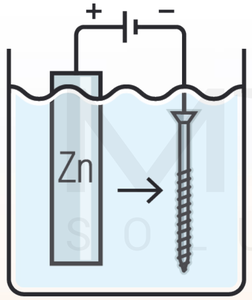
The difference is **when** and **how**!

	Internal Hydrogen Embrittlement (IHE)	Environmental Hydrogen Embrittlement (EHE)
Source	**During** the manufacturing process, typically during electroplating	**After** installation, typically introduced through moisture or corrosion
Whose Priority?	**MANUFACTURERS**	**INSTALLERS**

HYDROGEN EMBRITTLEMENT

IHE Sources





Acid Cleaning

- Before electroplating or coating
- *Ex.* $Fe(s) + HCl(aq) \rightarrow Fe(s) + H + \frac{1}{2}Cl_2(g) \rightarrow FeH(s)$

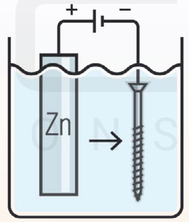
Electroplating Process

- Hydrogen production through electrolysis
- In some cases, an acidic solution is used in the plating process

HYDROGEN EMBRITTLEMENT

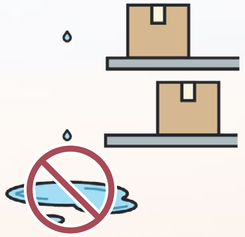
IHE Prevention Measures

Inhibitors in Acid Cleaning



Non-Hydrogen-Producing Plating Process

Choose a Less Susceptible Material



Dry Storage

HYDROGEN EMBRITTLEMENT

EHE Sources

Corrosion

$Fe(s) \rightarrow Fe^{2+} + 2e^-$

$2e^- + 2H_2O \rightarrow H_2 + 2OH^-$

$2OH^- + Fe^{2+}(aq) \rightarrow Fe(OH)_2$

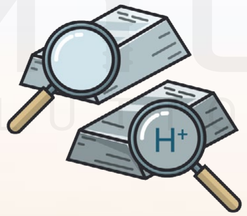
Acid Washes

Avoid screws and wood areas near screws

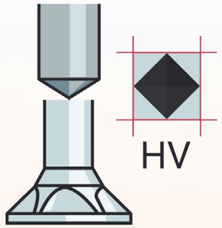
HYDROGEN EMBRITTLEMENT

EHE Prevention Measures

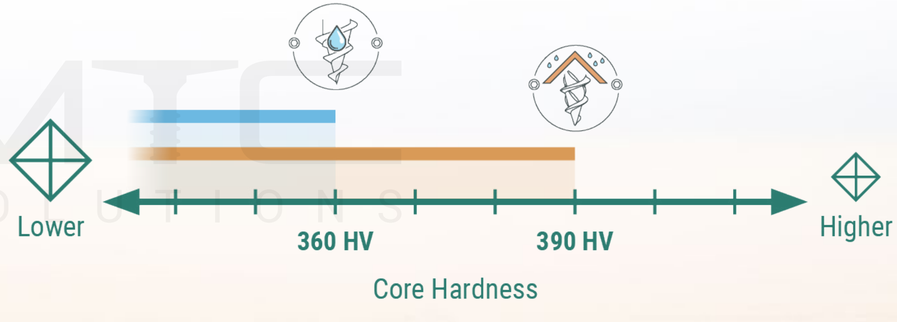
Follow Design Standards for Dry and Wet Service Conditions

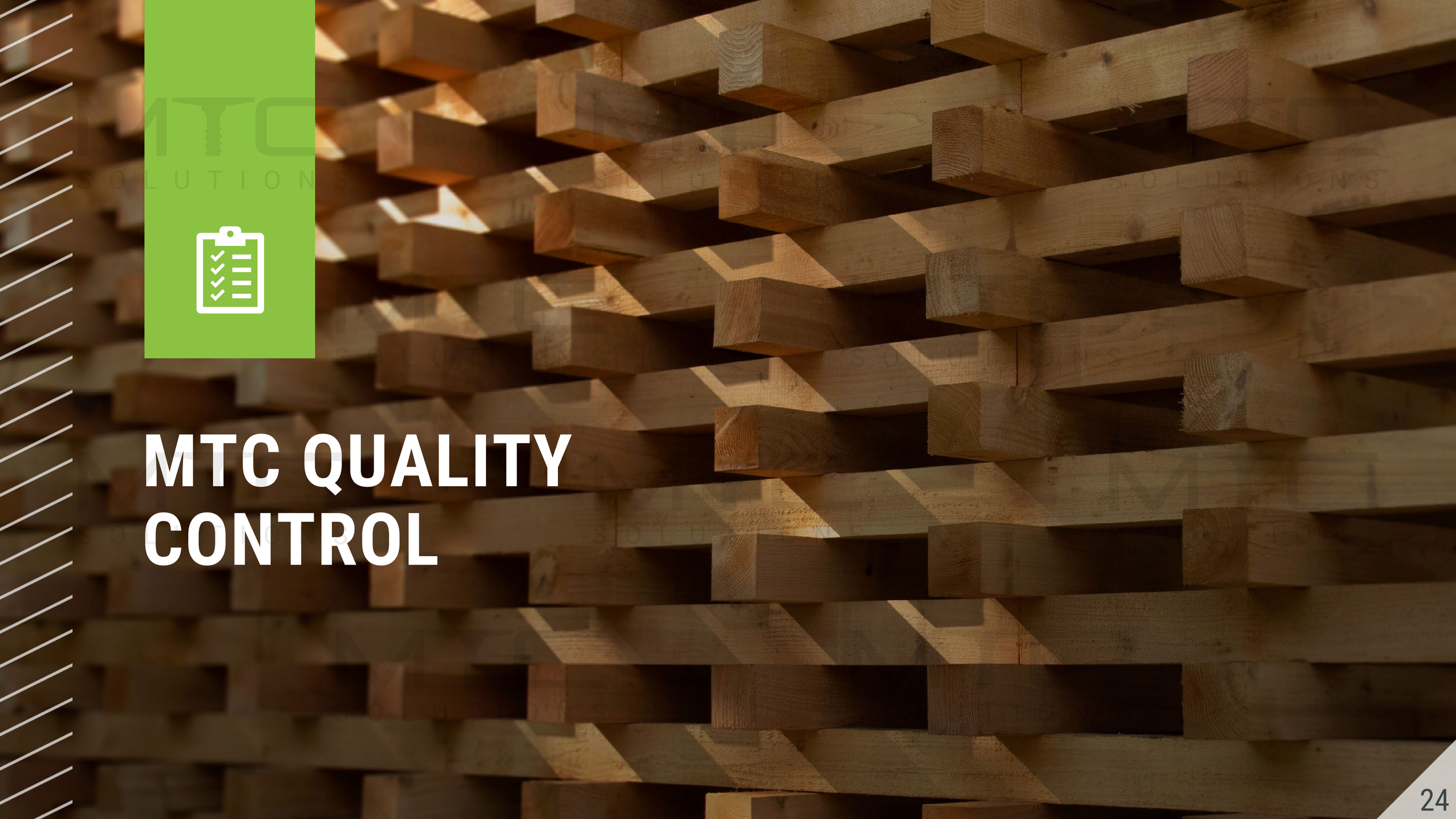


Choose a Less Susceptible Material



Dictate a Screw Hardness



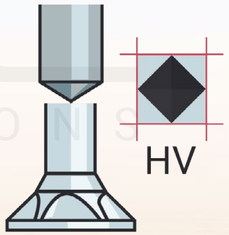


MTC QUALITY CONTROL

MTC QUALITY CONTROL

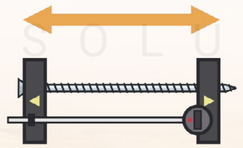
The Focus

Batch Tracking and Sampling



Core Hardness Testing

Vickers Hardness



Tension Testing

Custom apparatus expertly developed

Records and Documentation

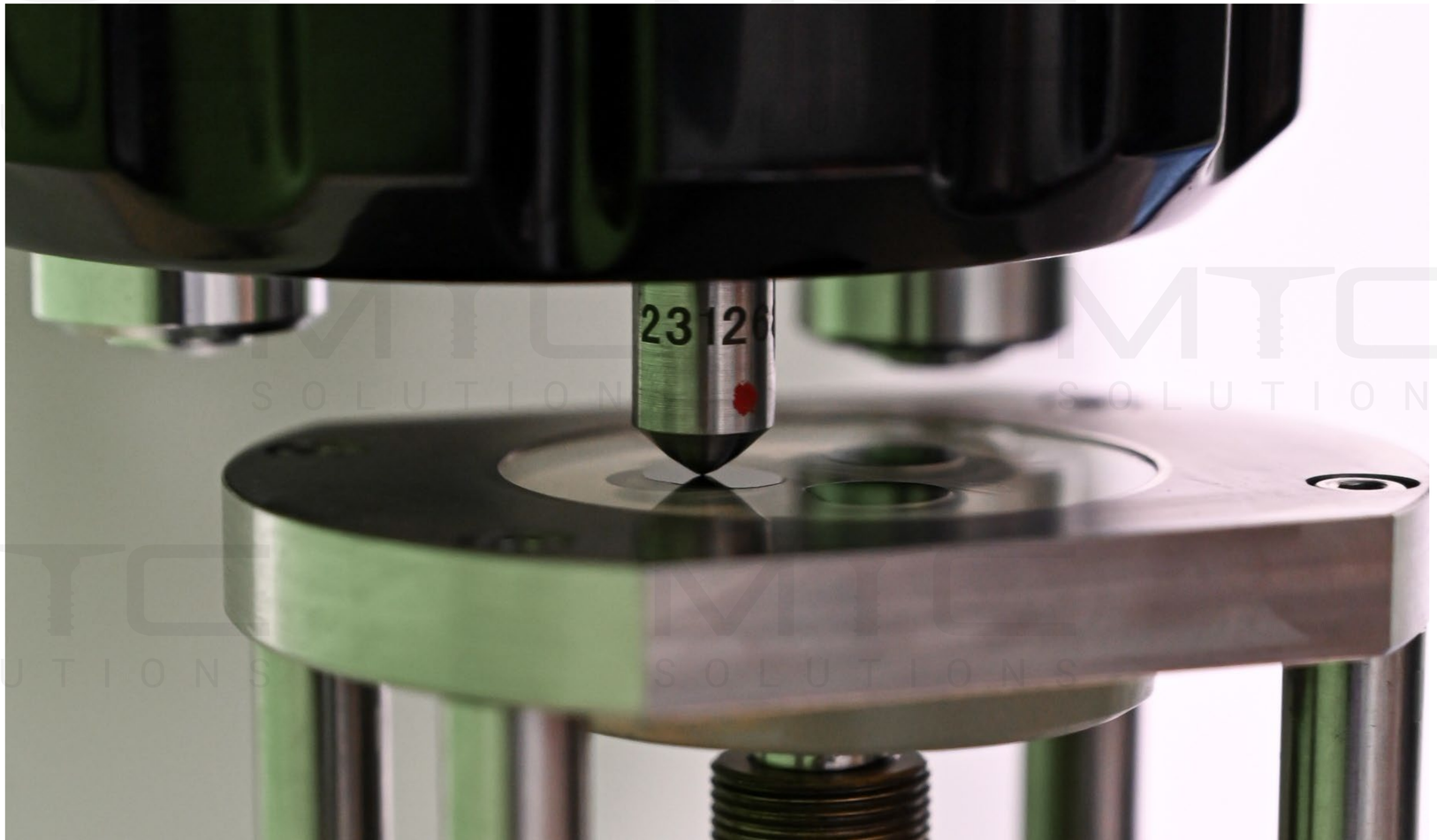
Storage of physical and digital records for an extended period

Note: *MTC's quality control is in addition to the manufacturer's program*

MTC QUALITY CONTROL

The Focus

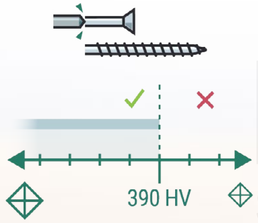
Core Hardness Testing

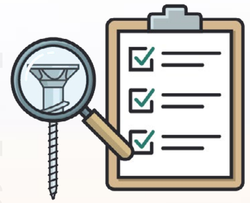


HOW TO SPECIFY

HOW TO SPECIFY

Specific Requests to Make





Specify Hardness Limits

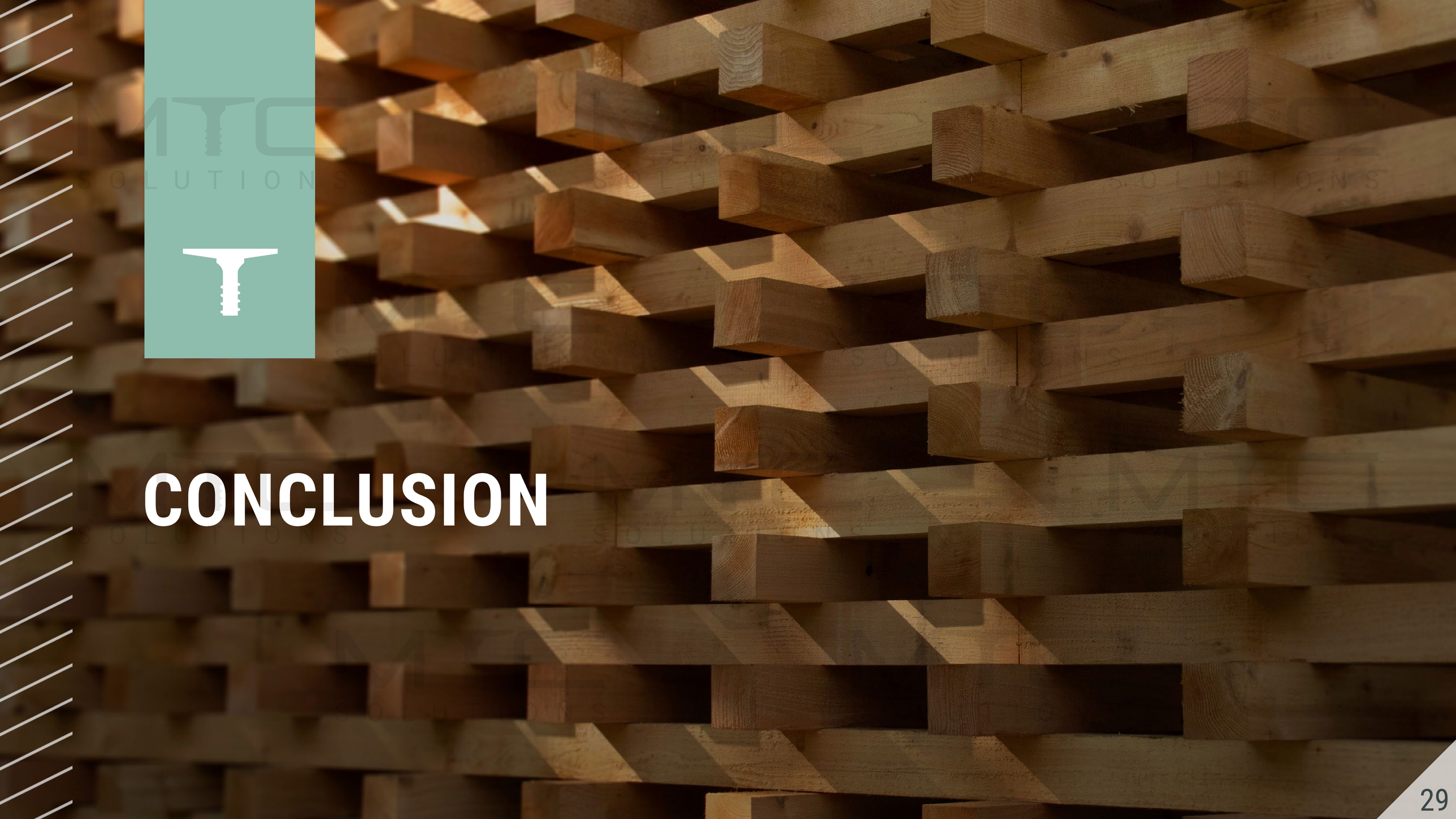
- ≤ **390 HV** for dry service
- ≤ **360 HV** for wet service

Request QC Verification

- Signed letter of assurance
- Request hardness results for each batch of screws used on a project
- Request IHE verification results

Request for Review

- Have the supplier explain the QC program in place to ensure IHE risk is mitigated
- Ask your supplier what an engineer or installer can do for EHE



CONCLUSION

CONCLUSION

Significant Points to Remember

1. What does a screw ***need*** for an HE failure?
2. IHE vs EHE?
3. Code vs Best safe practice – an ethical dilemma
4. What can an Engineer do?

At MTC Solutions we guarantee
that we are doing what is right

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QUALITY CONTROL

RESEARCH & DEVELOPMENT


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