Johnson Matthey
Inspiring science, enhancing life

Americas hydrogen and syngas technical training seminar

Catalyst loading and unloading

Jenson Jen Jacob

Remember, safety first!

Safety – measure and escape

Dedicated monitors

Multi monitor

Escape Hood

N95 mask

Tyvek suit

Safety – helpful tips!

Contents

Steam reformer

Contents

Steam reformer

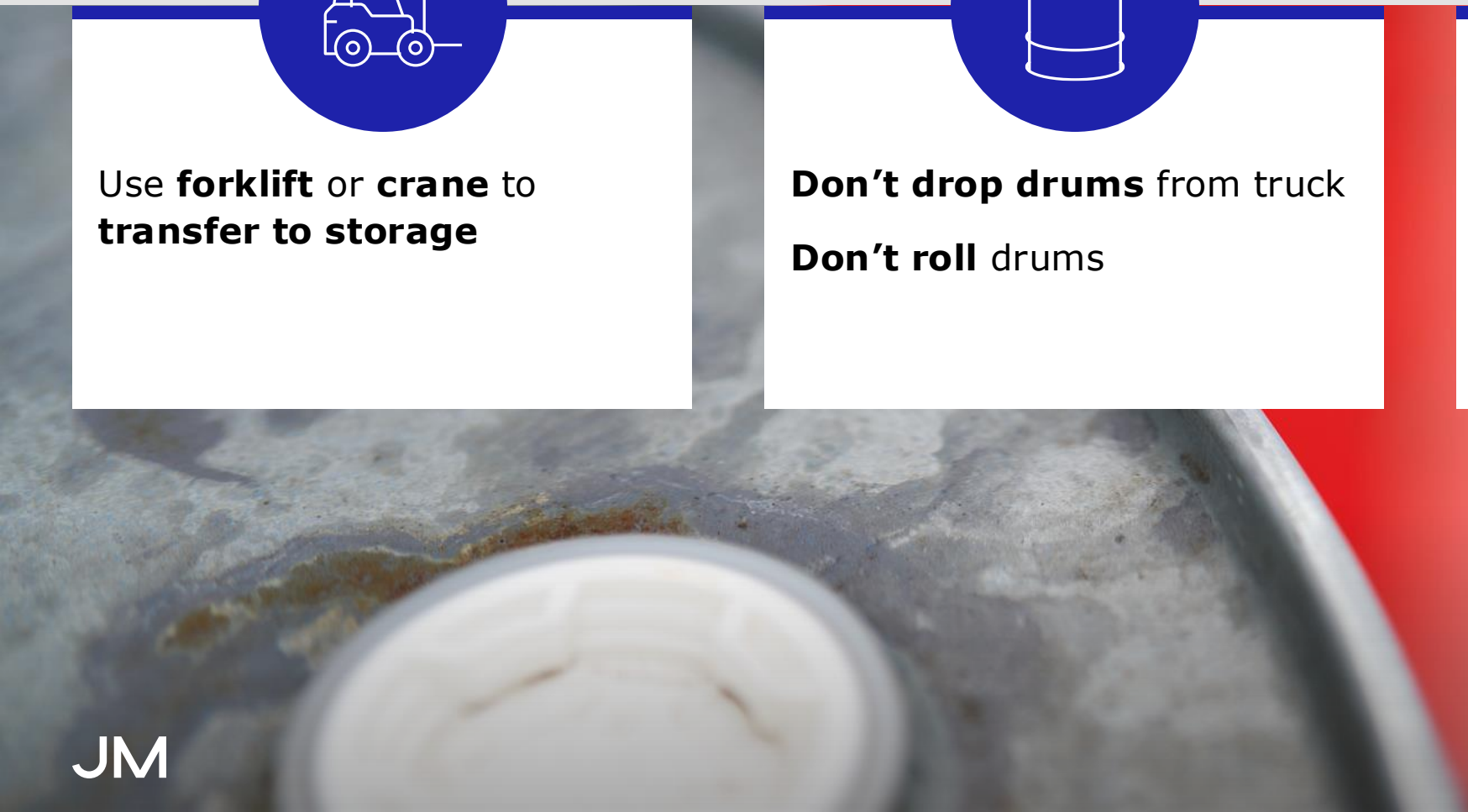
Steam reformer – handling

Use **forklift** or **crane** to **transfer to storage**

Don’t drop drums from truck

Don’t roll drums

Inspect drums for damage and **repair broken lids**



Steam reformer – storage

Temperature range: -120°F to +120°F (-84°C ~ 50°C), provided it is kept dry

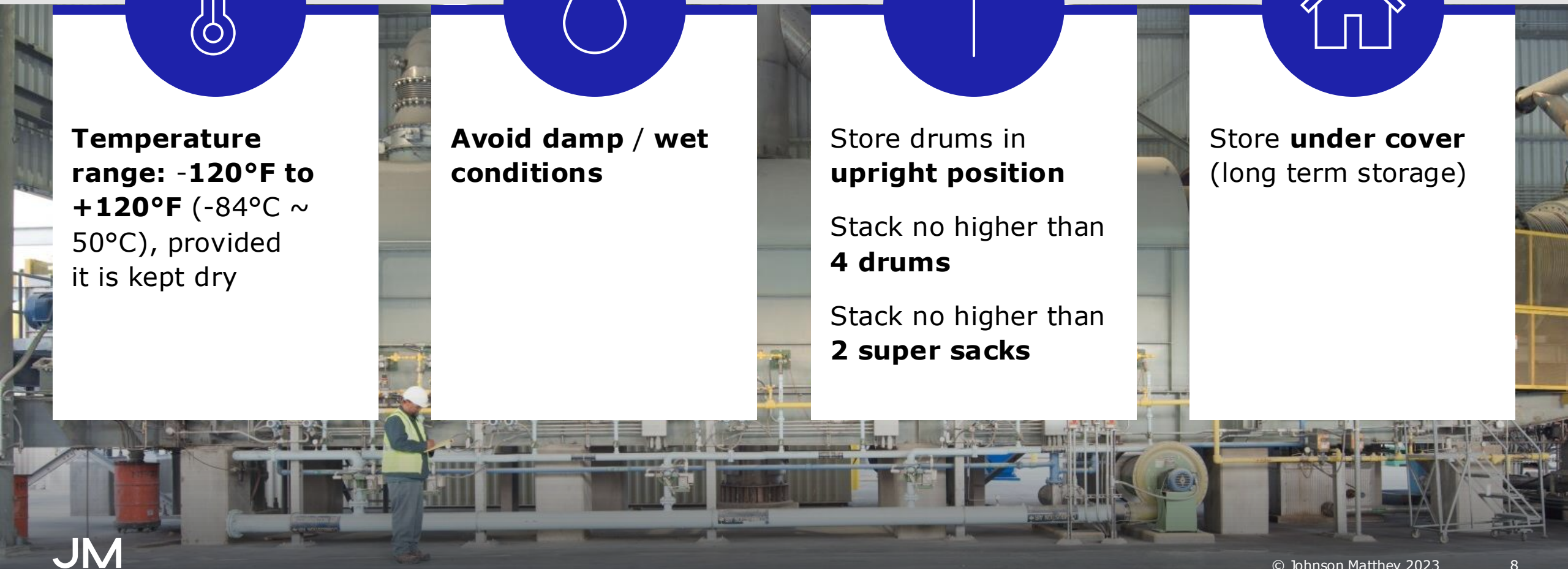
Avoid damp / wet conditions

Store drums in **upright position**

Stack no higher than **4 drums**

Stack no higher than **2 super sacks**

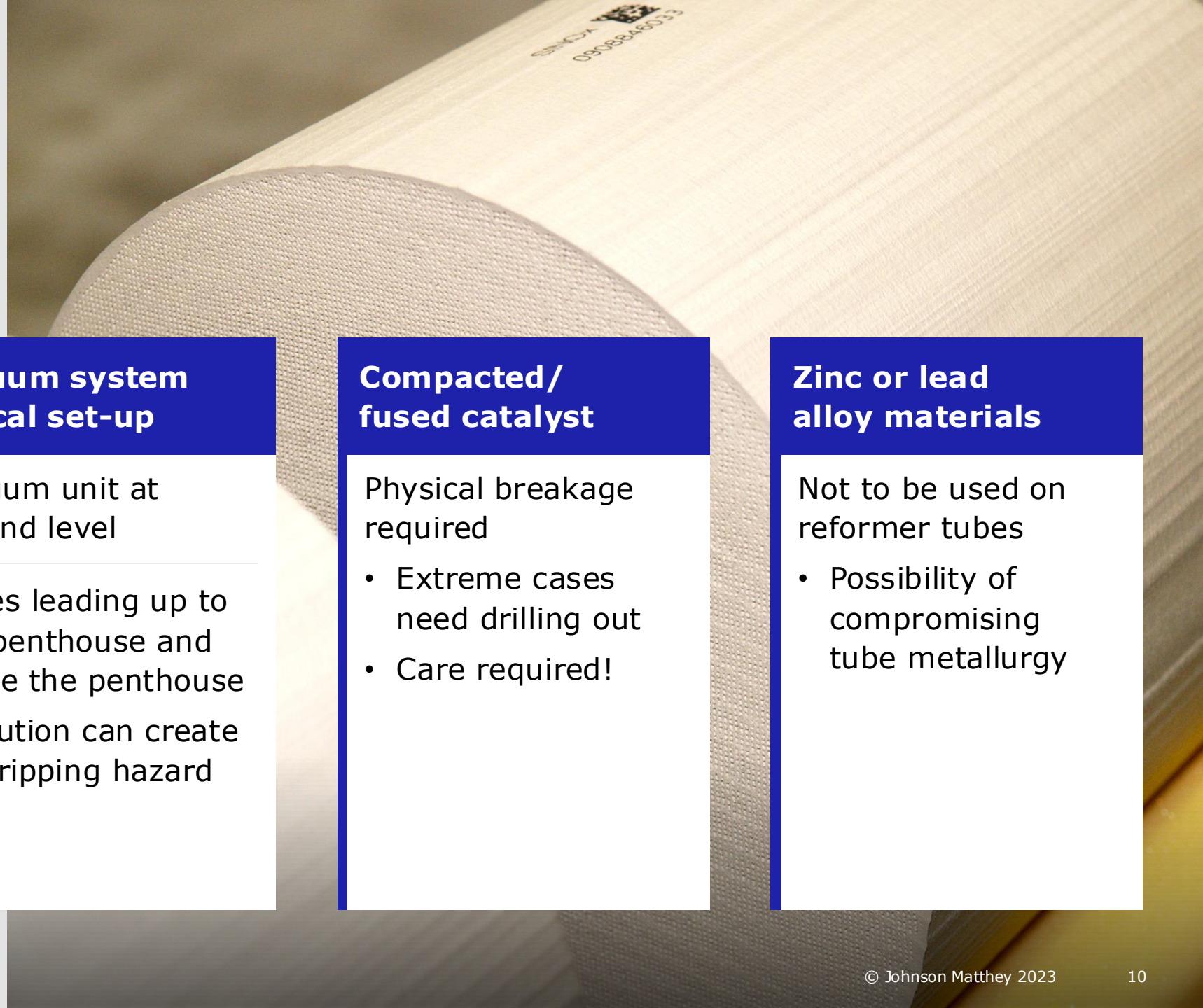
Store **under cover** (long term storage)



Contents

Steam reformer

Steam reformer – catalyst discharge



Discharge methods

Bottom discharge is very rarely possible

Usual method is vacuum extraction from top

Vacuum system typical set-up

Vacuum unit at ground level

Hoses leading up to the penthouse and inside the penthouse

- Caution can create a tripping hazard

Compacted/ fused catalyst

Physical breakage required

- Extreme cases need drilling out
- Care required!

Zinc or lead alloy materials

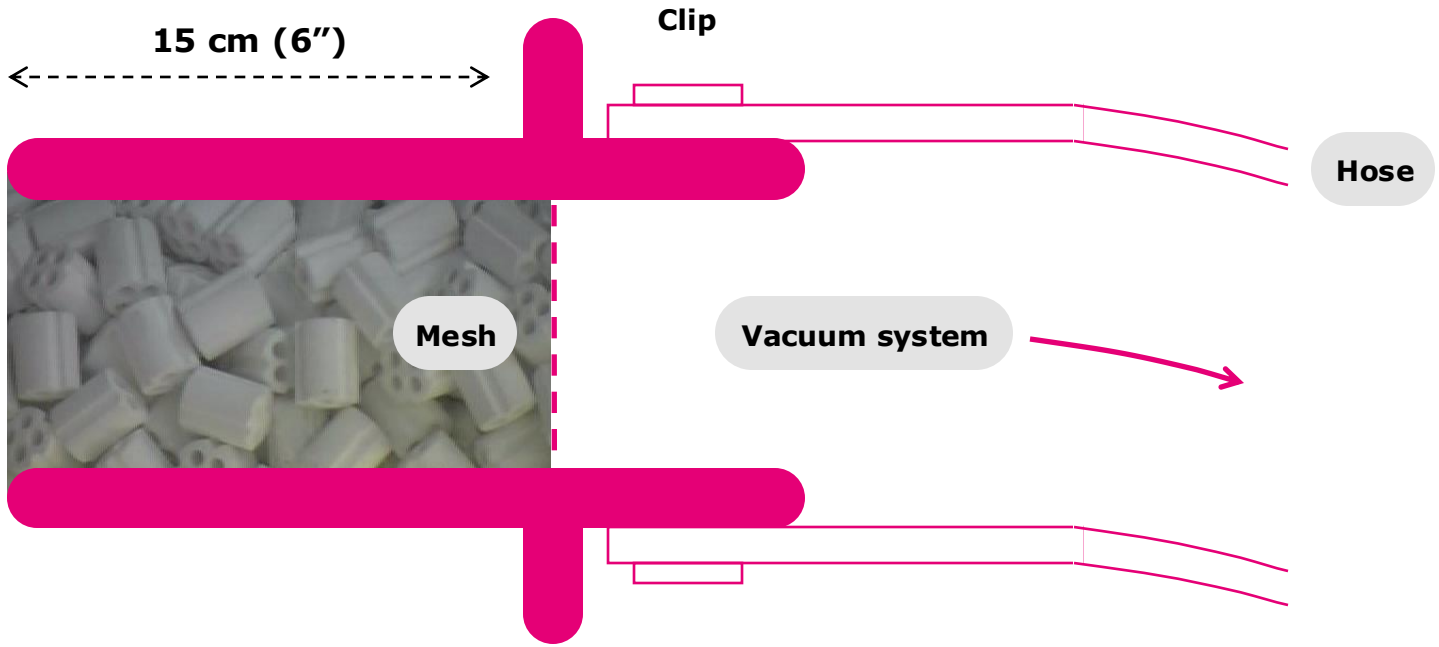
Not to be used on reformer tubes

- Possibility of compromising tube metallurgy

JM

Steam reformer – catalyst sampling

When there's the need to know where the catalyst sample is from and avoid breakage in vacuum system



Contents

Steam reformer

Steam reformer – loading objectives

Loading ideally aims to achieve:

Uniform catalyst packing in every tube to give

- Uniform gas flow throughout the Reformer

Resulting in

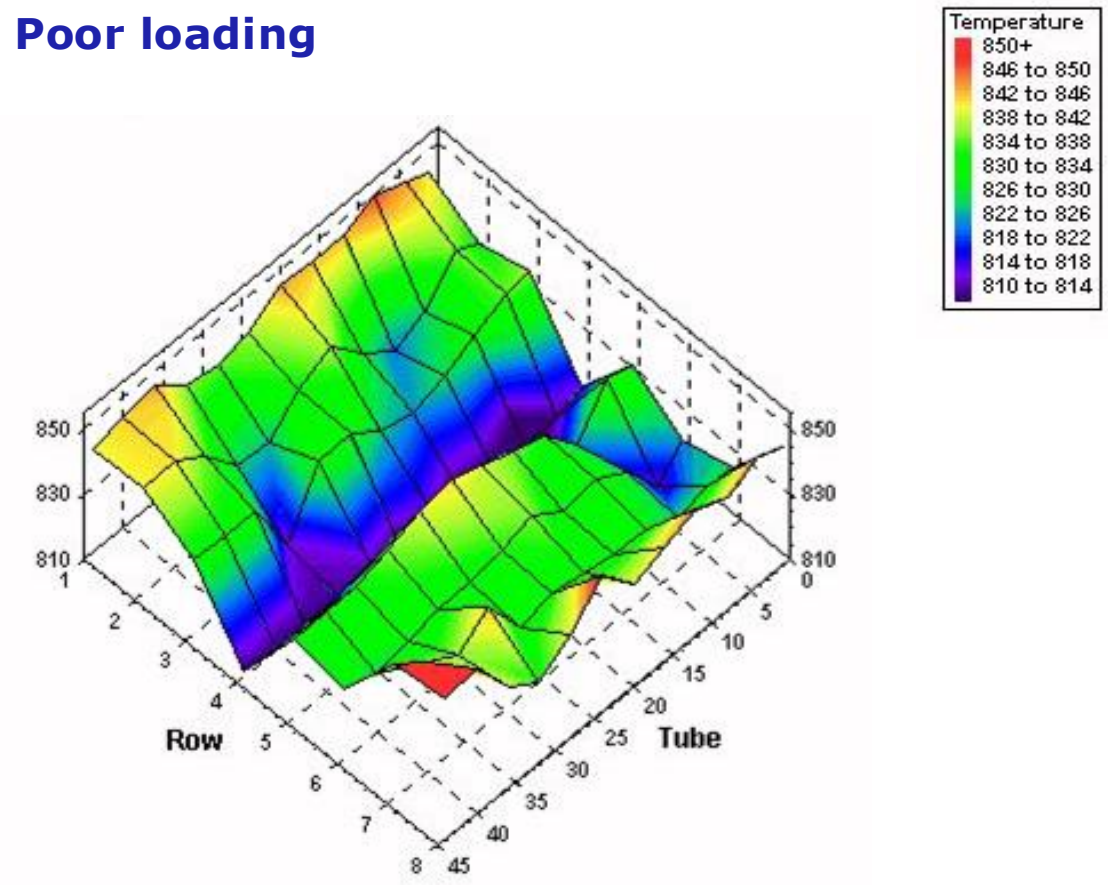
Small pressure drop variation across the reformer

Even temperature profile over the furnace

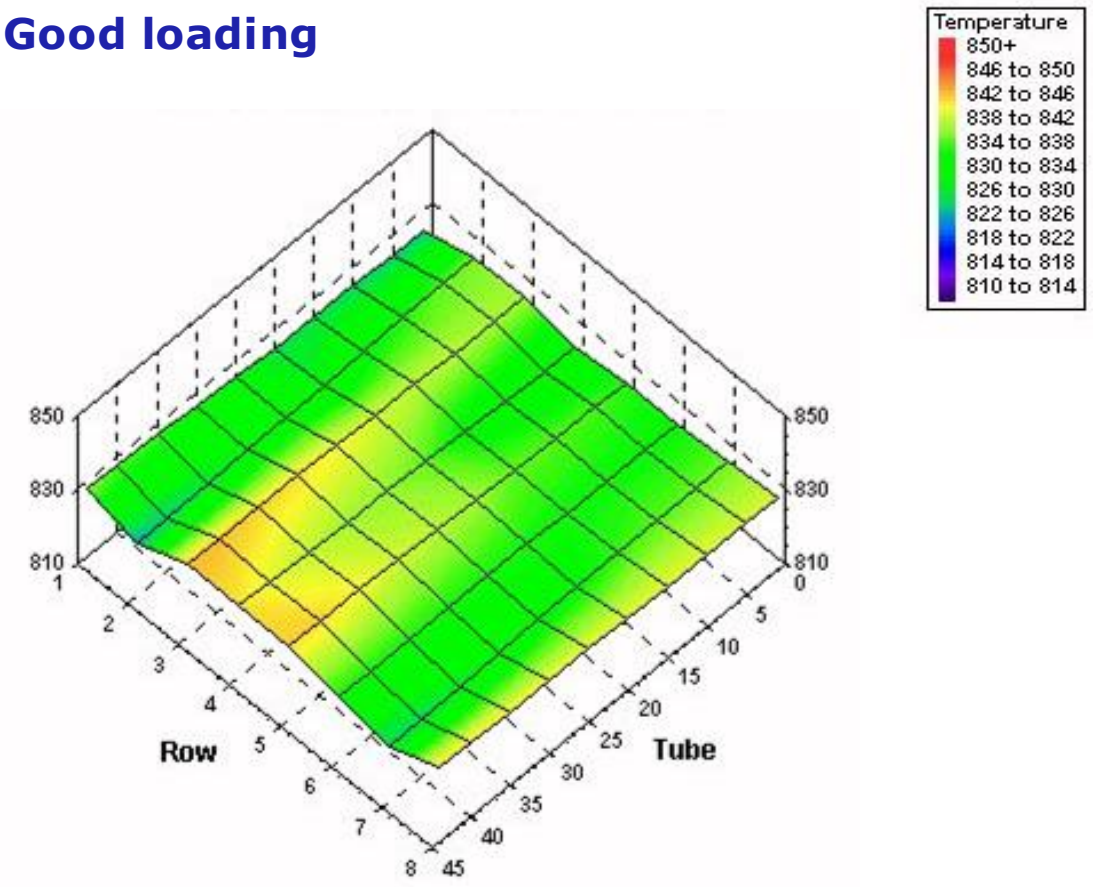
Most effective use of the catalyst

Steam reformer – loading objectives

Poor loading

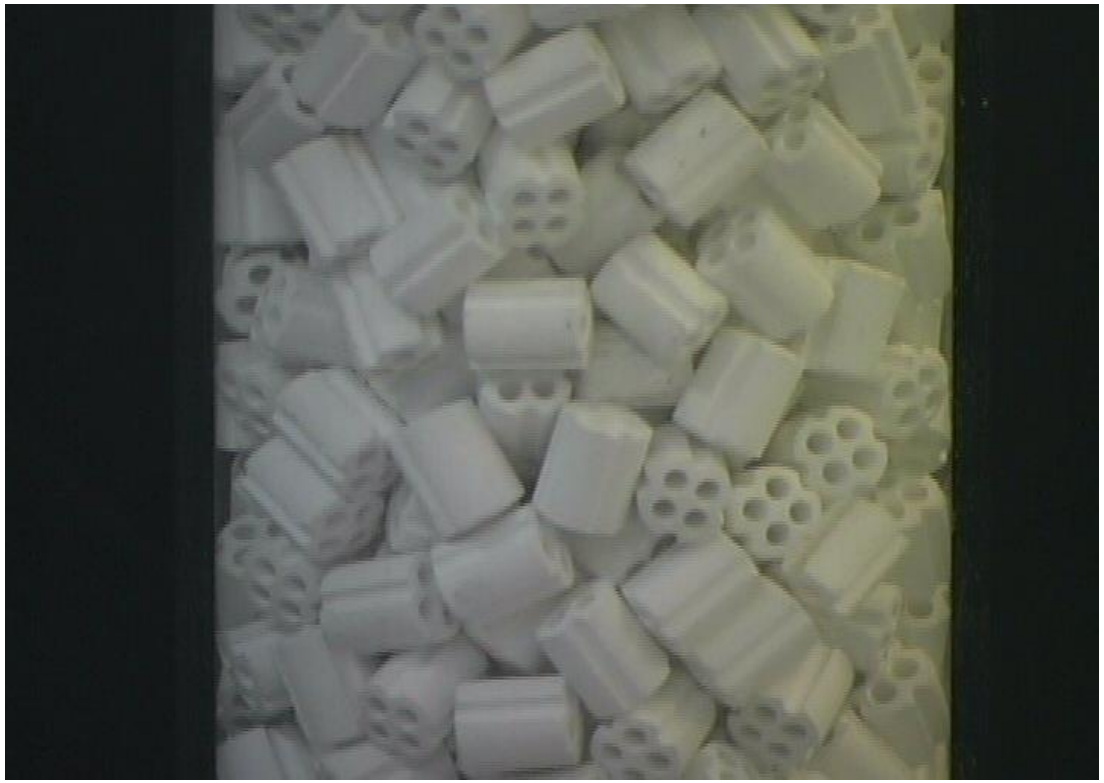


Good loading

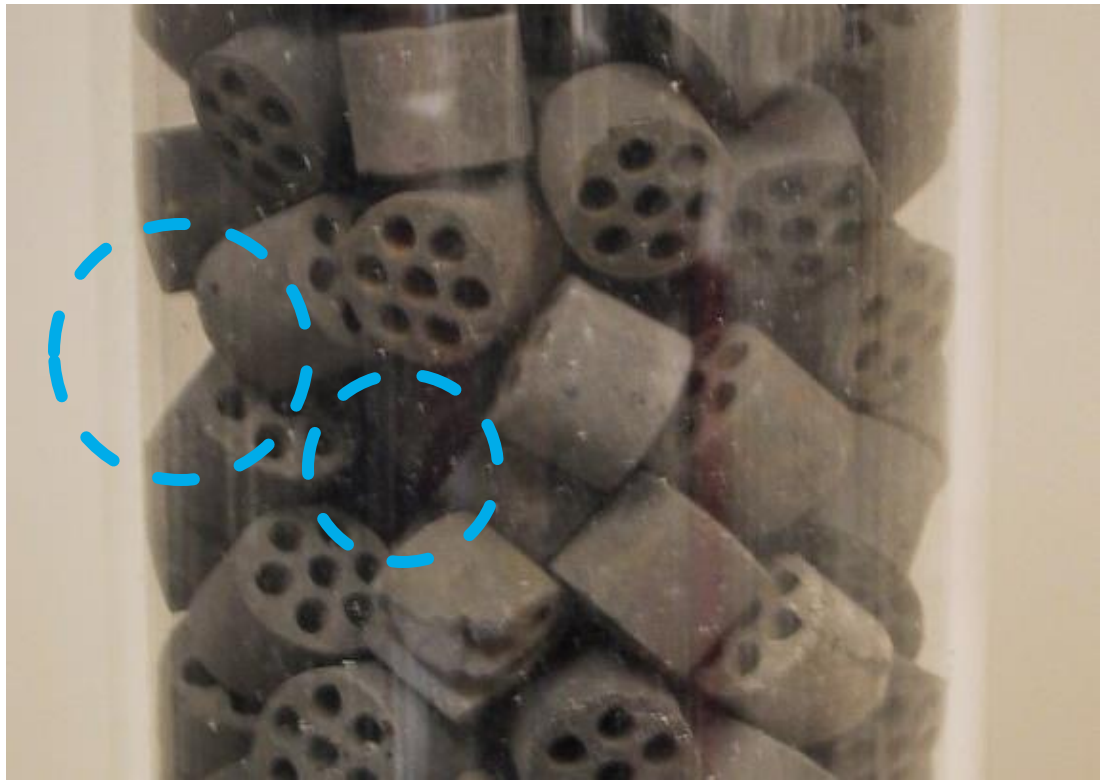


Steam reformer – loading objectives

Small voids = good packing



Large voids = poor packing



Steam reformer – poor loading

Voids and bridging within catalyst

Observed hot spots and bands

Giraffe necking

Tiger tails

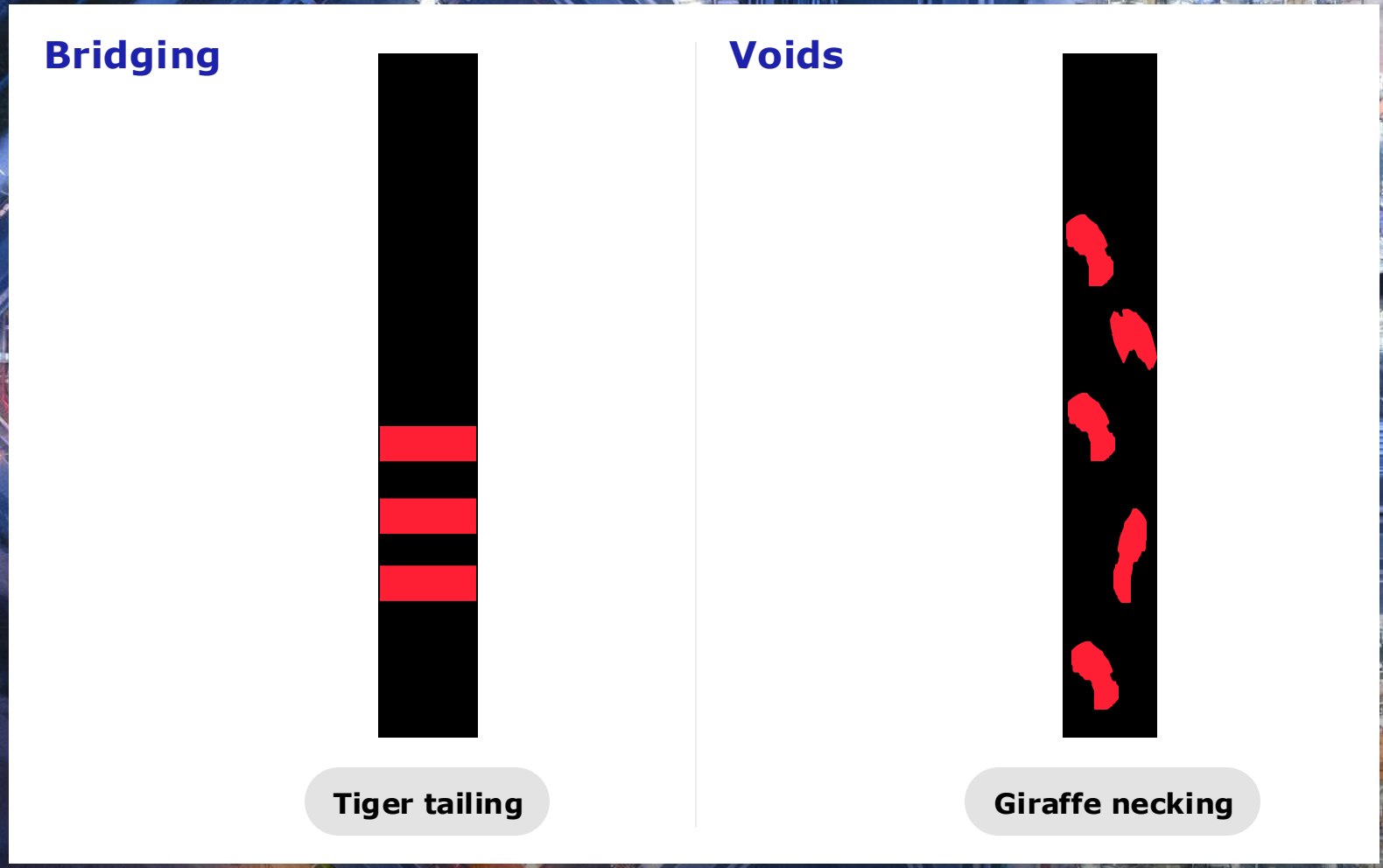
Occurrence influenced by

Catalyst shape and size

Miscare with loading

Increases localized TWT by 54°F (30°C) for small voids

Large voids are worse

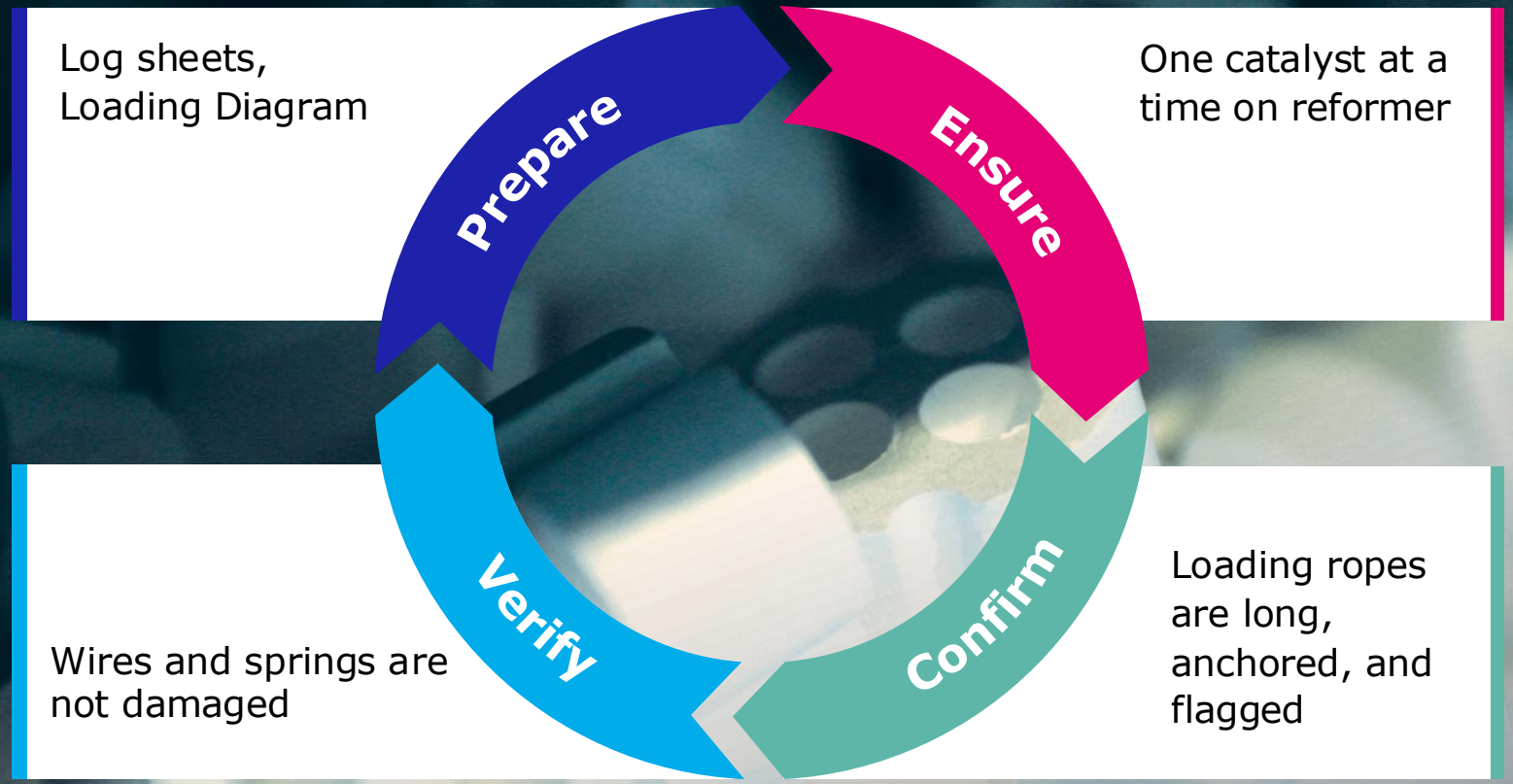


JM

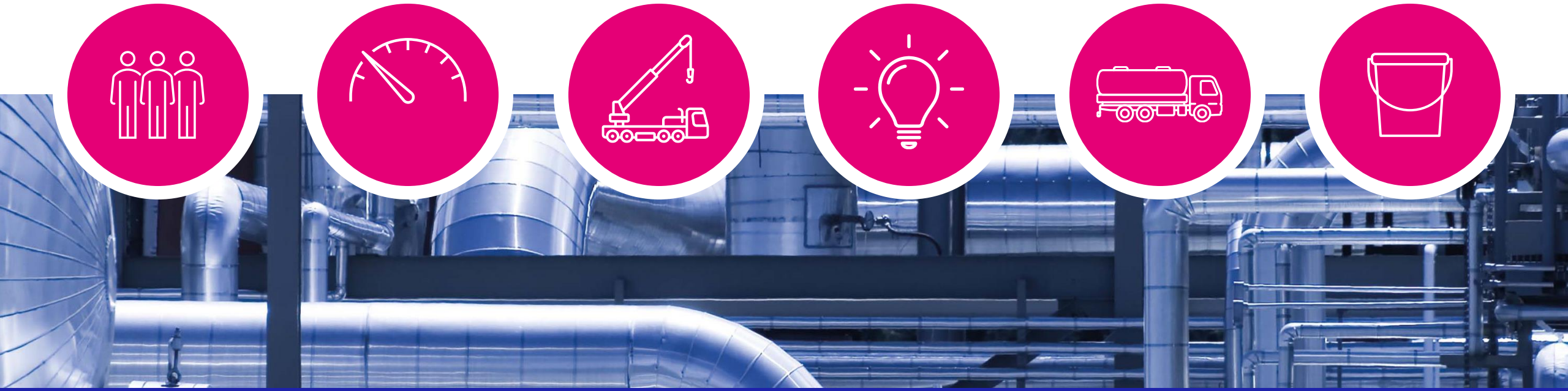
Contents

Steam reformer

Steam reformer – pre-loading principles



Loading principles – facilities required



Loading principles – empty tube inspection

Tube inspection

Inlet and exit pigtails
not blocked - Internal surface **smooth**

Catalyst support grids
undamaged and **in place**

Loading principles – key parameters

Pressure drop (dP) is the critical measure throughout the loading

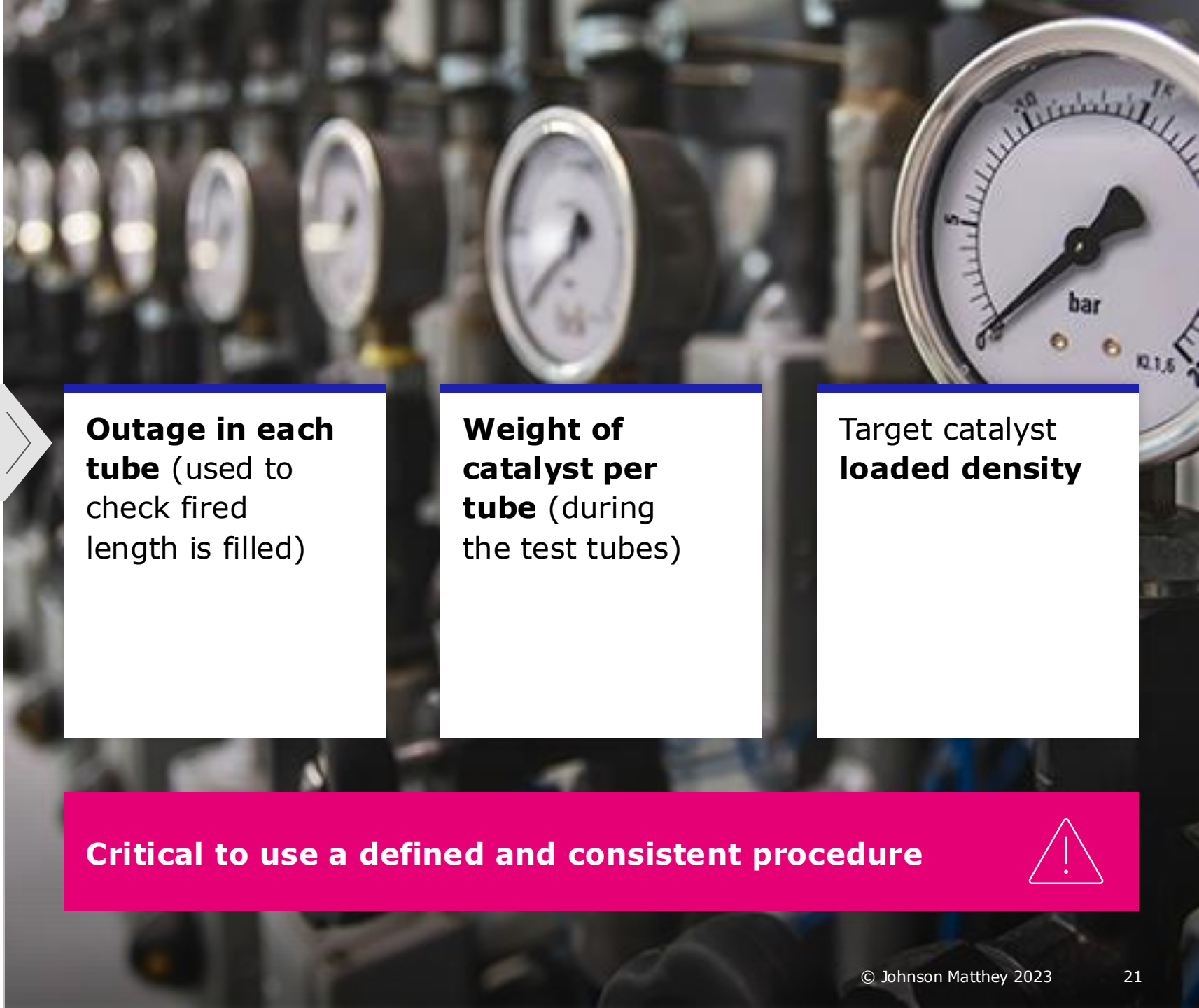
Important information to review is:

Outage in each tube (used to check fired length is filled)

Weight of catalyst per tube (during the test tubes)

Target catalyst **loaded density**

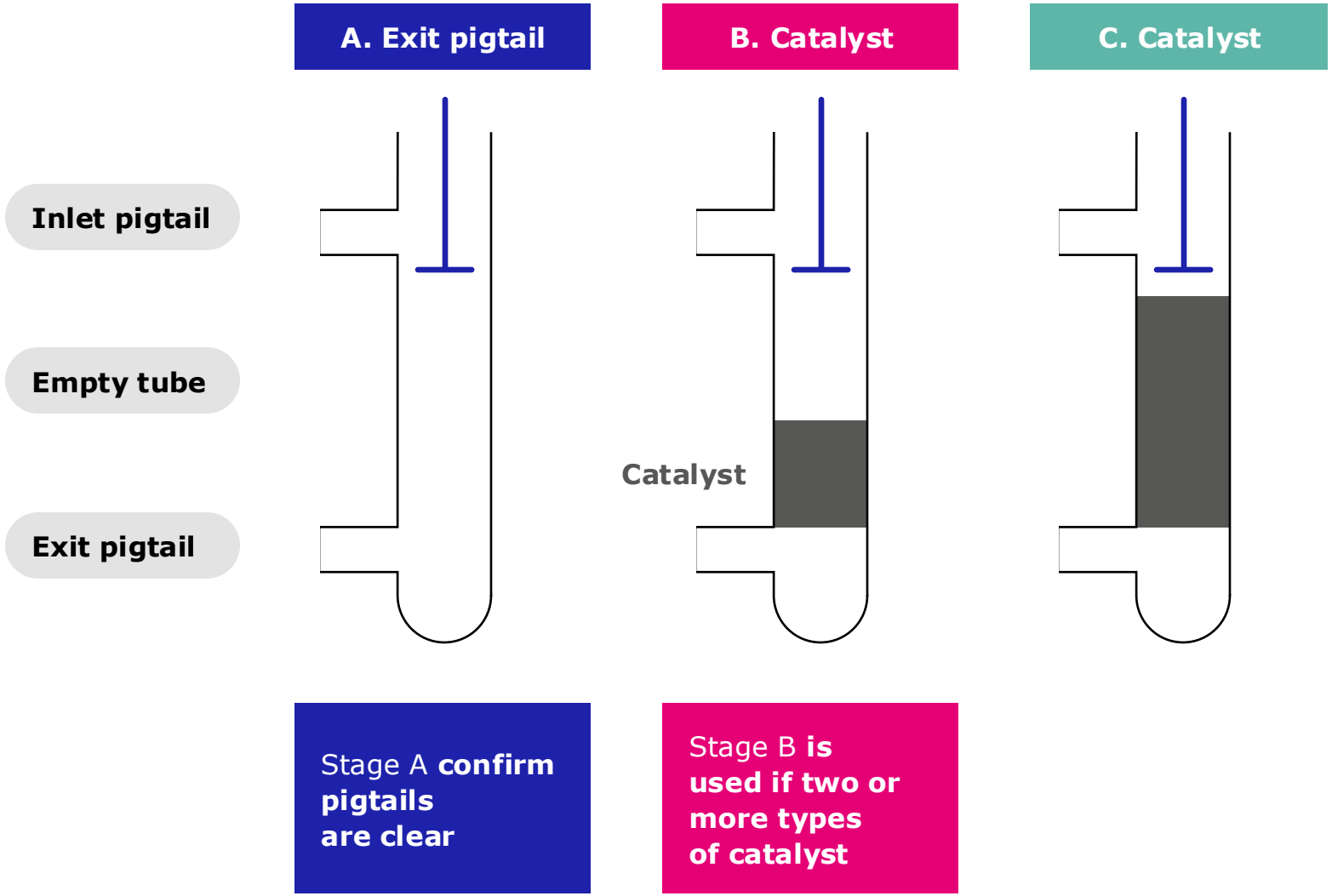
Critical to use a defined and consistent procedure



JM

Loading principles – dP procedures

dP measurement critical to success - 3 steps



Loading principles – procedure checklist

When loading	When the loading is complete
Check dP and outage after first layer of catalyst is loaded	Measure final dP
Adjust dP if spread more than ± 9%	Measure final outage • Ensure heated length filled and allowance made for settling
If more than one catalyst type, check after each layer and measure outage for each level	Adjust dP if spread more than ± 5%

Steam reformer – loading principles

Adjustment of pressure drop

01

First – target low dP tubes

Vibrate to settle catalyst
(Rubber mallet often used)

Do not vibrate excessively
(Can affect surrounding tubes)

Top up catalyst if needed
(Within the acceptable outage)

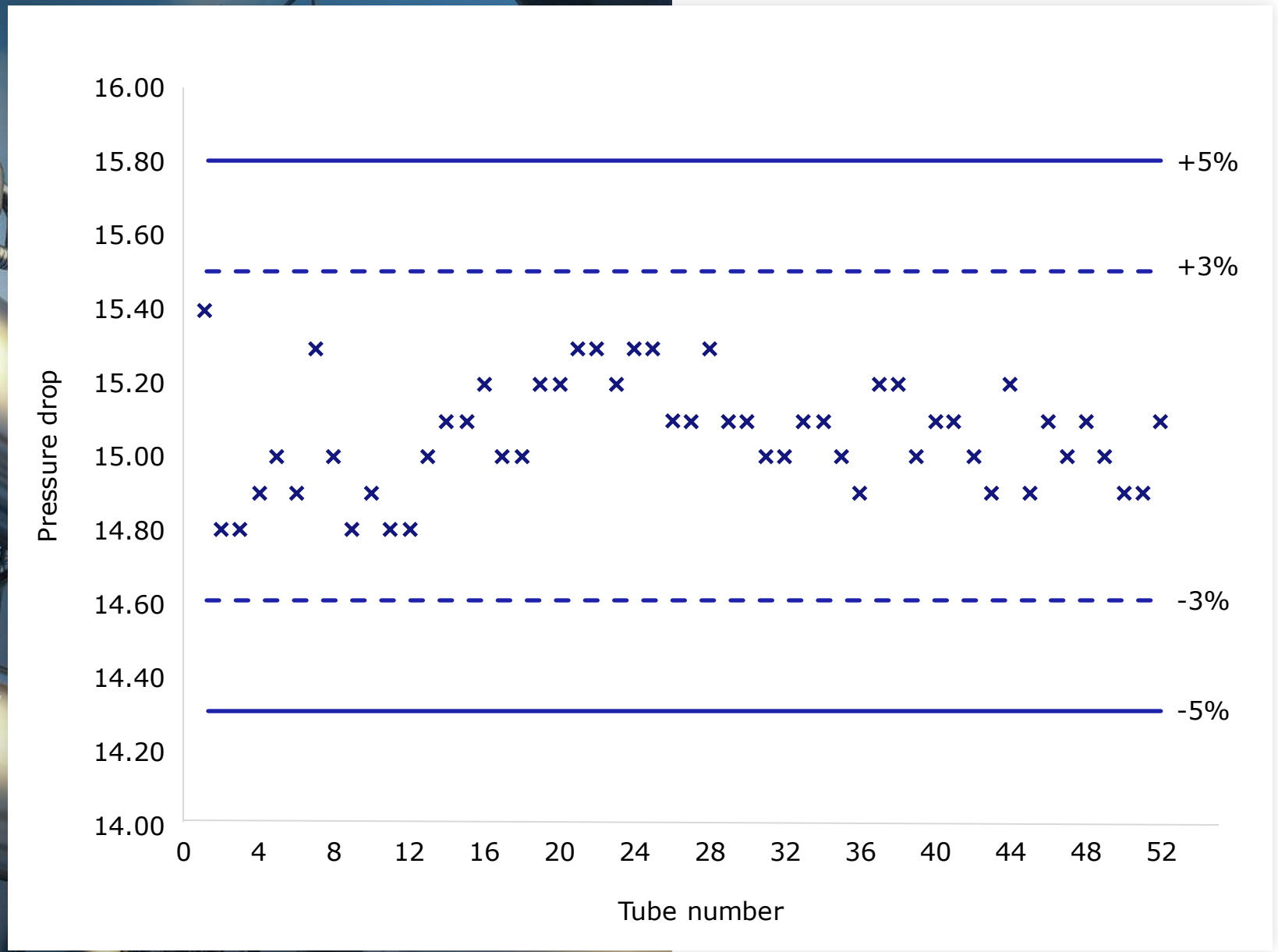
Recheck dP range

02

Secondly – discharge and re-load high dP tubes

JM

Steam reformer – final dP

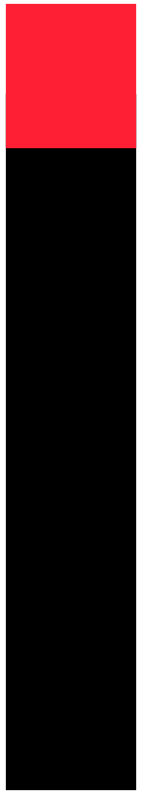


Steam reformer – loading principles

Loading issues affect tube appearance

- Insufficient catalyst
- Settling after poor loading
- Over-compaction/breakage
- Catalyst milling

All lead to…



Hot zone near furnace roof – no catalyst present

JM

Contents

Steam reformer

Steam reformer – measure of dP

dP measurement principles

Provide fixed air flow

(Regulated flow through orifice)

Mass flow rate through orifice function of

Upstream pressure (known)

Orifice diameter (known)

Temperature (known)

Downstream pressure is measure of dP

JM

Contents

Steam reformer

Steam reformer – loading techniques

Three techniques

01 **Water-fill method** - obsolete

02 **Sock loading** - nearly obsolete

03

Dense methods

Most common method

Used increasingly since mid-1990s

Various proprietary methods exist

JM

Steam reformer – loading techniques

Dense method

Uses device to break catalyst free fall in tubes

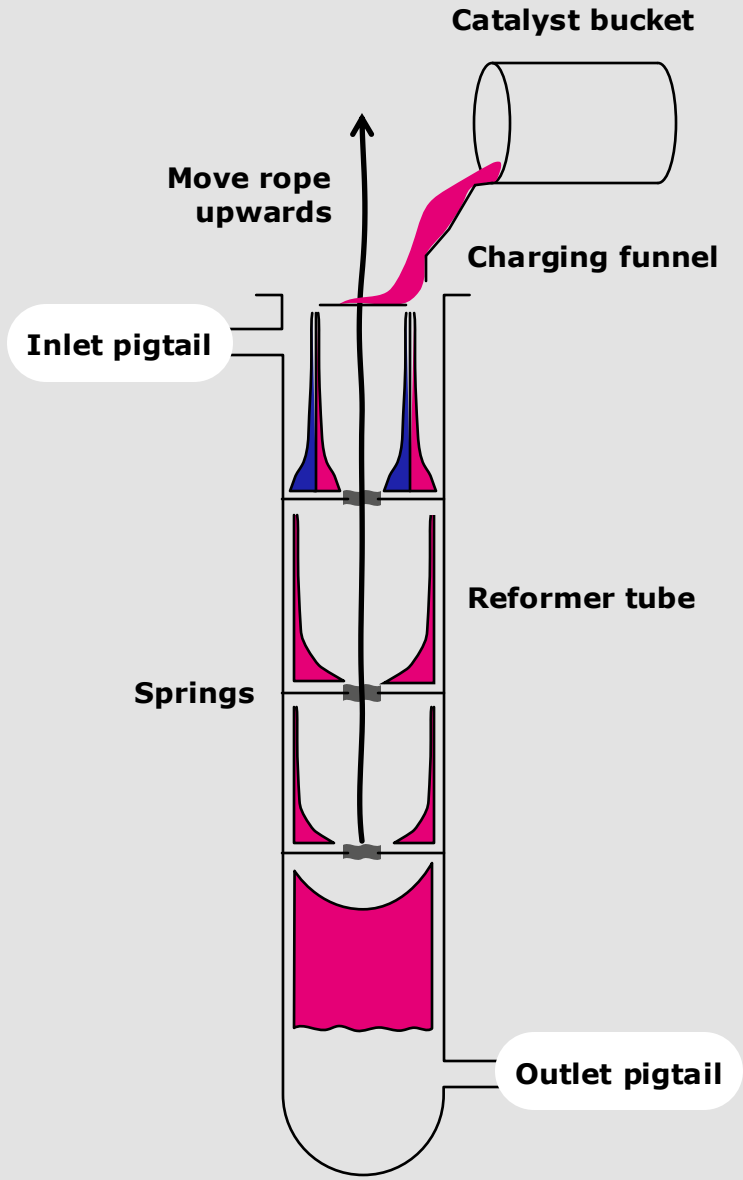
Springs on spiral

Knotted line

Discs

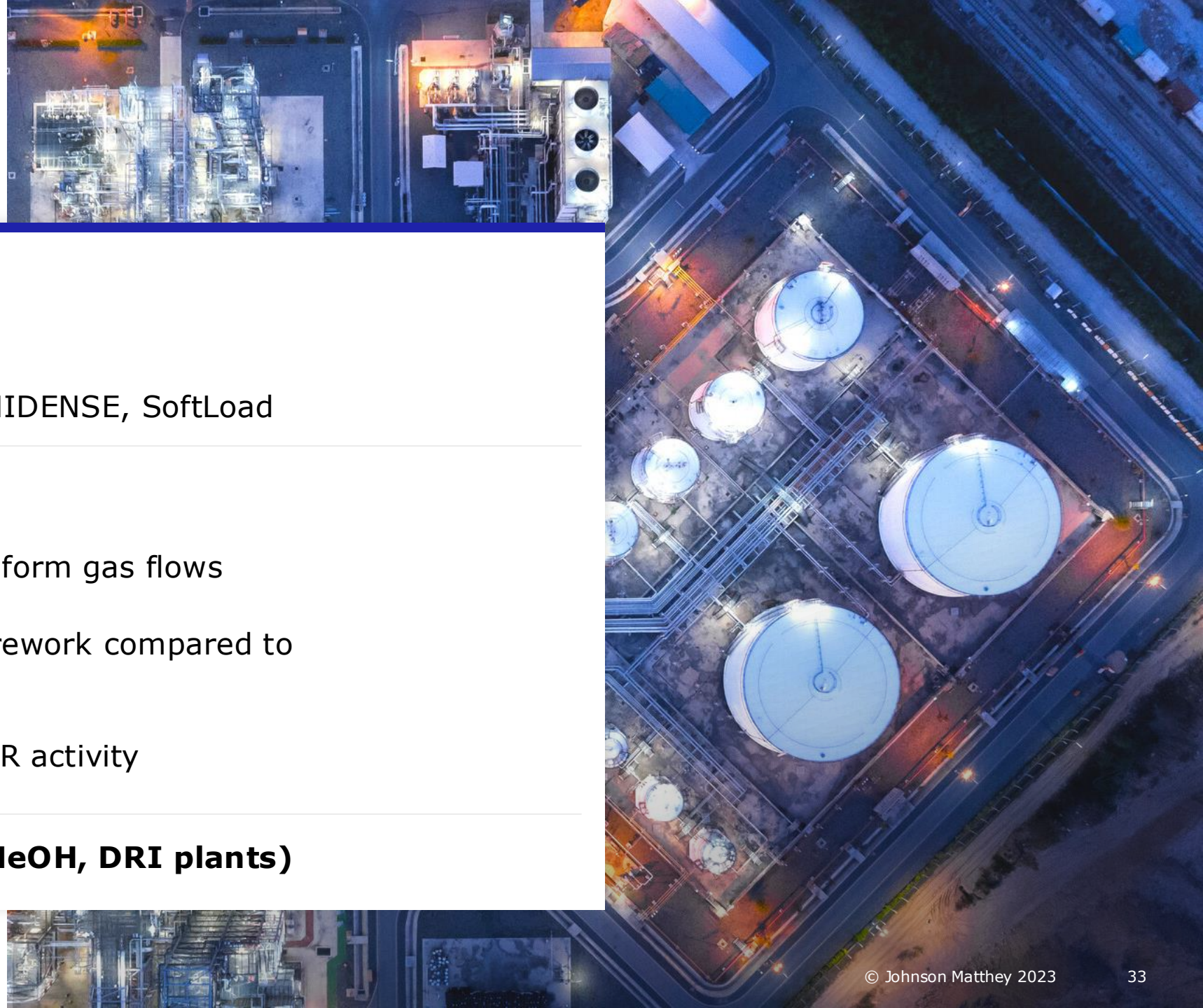
Brushes

Raise rope as tube fills



JM

Steam reformer – loading techniques



Modern methods

Multiple systems now proven

CATCADE, UNILOADER, CALM, UNIDENSE, SoftLoad

Advantages

01 Lower dP spread – more uniform gas flows

02 Faster loading (70%); less rework compared to historical sock loading

03 Denser packing – higher SOR activity

Long reference list (H_2, NH_3, MeOH, DRI plants)

JM

Contents

Steam reformer

Summary

01 Catalyst loading has a **significant impact** on how successfully the **reformer will run for the life of the catalyst**

02 **Dense method most commonly used**

03 **Pressure drop** is a **crucial value** to consider when **loading**

04 Catalyst dP spread of **± 5% easily achievable**


JM
Johnson Matthey
Inspiring science, enhancing life