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Johnson Matthey
Inspiring science, enhancing life

# Americas hydrogen and syngas technical training seminar

Catalyst loading and unloading

Erick Yspango

# Remember, safety first!

# Safety – measure and escape


**Dedicated monitors**

**Multi monitor**


**Escape Hood**


**N95 mask**

**Tyvek suit**

# Safety – helpful tips!

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## Steam reformer

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## Steam reformer

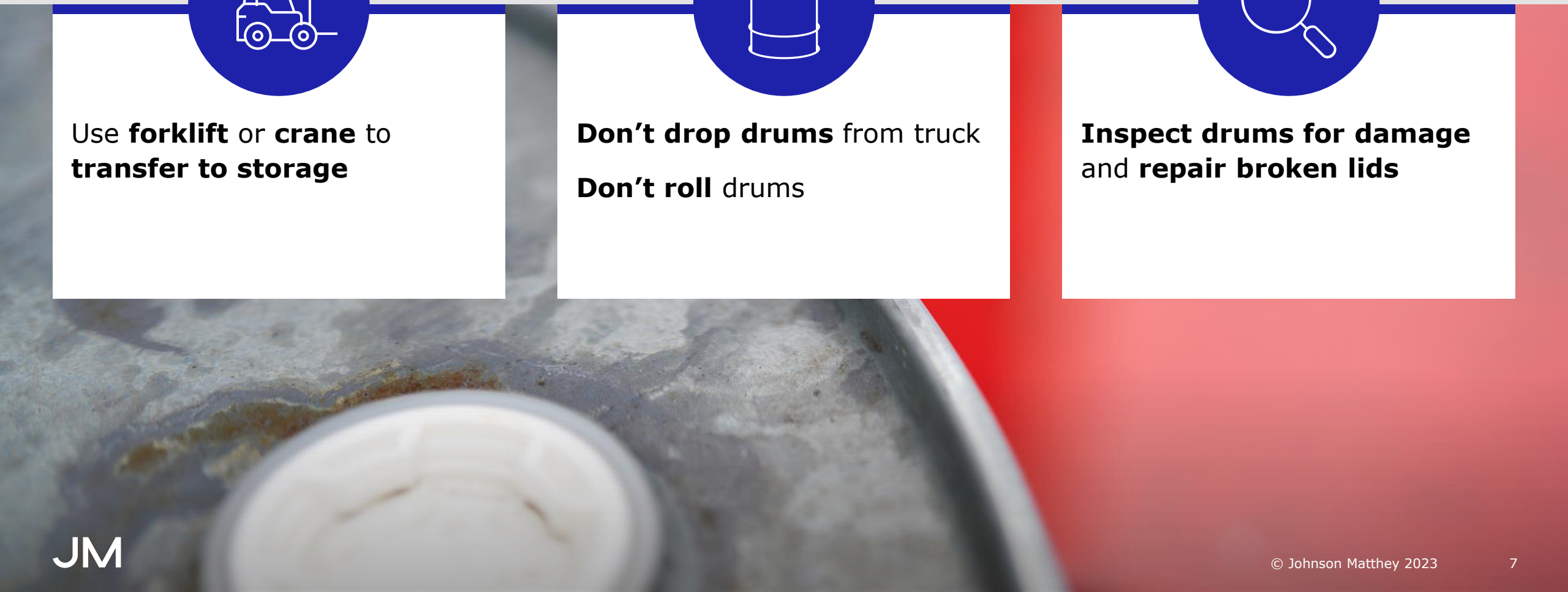
# Steam reformer – handling

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

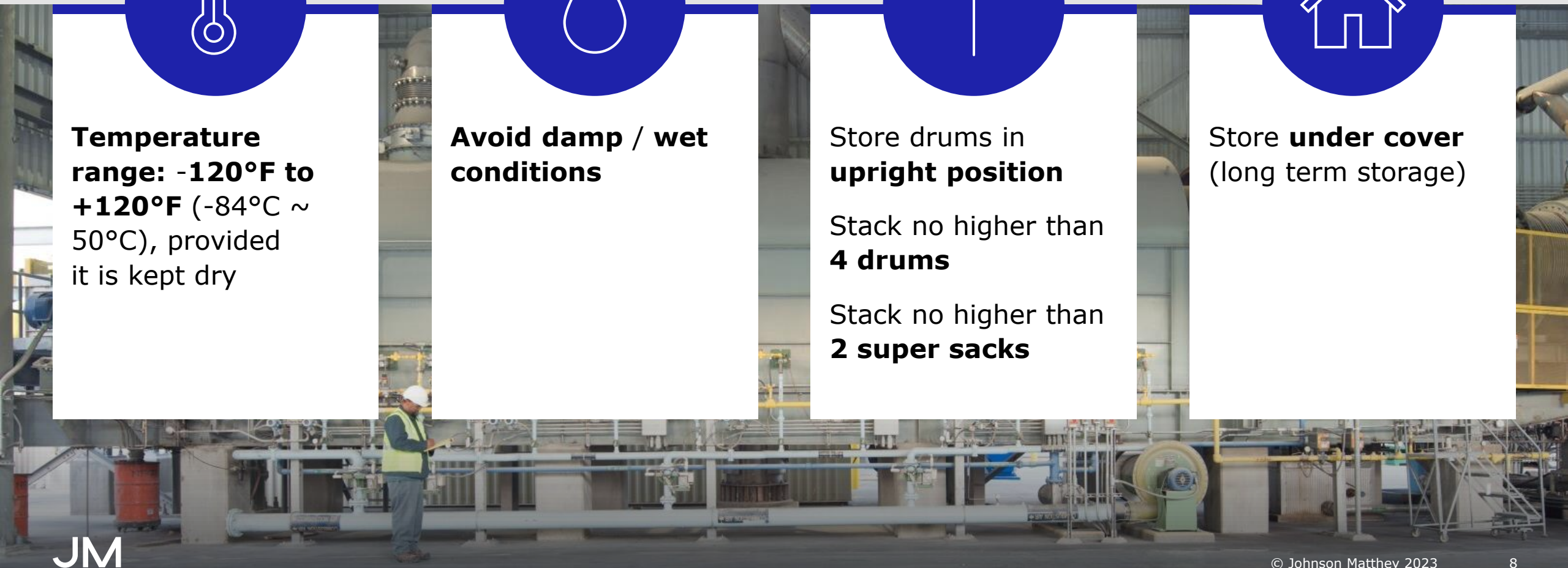
**Avoid damp / wet conditions**

Store drums in **upright position**

Stack no higher than **4 drums**

Stack no higher than **2 super sacks**

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



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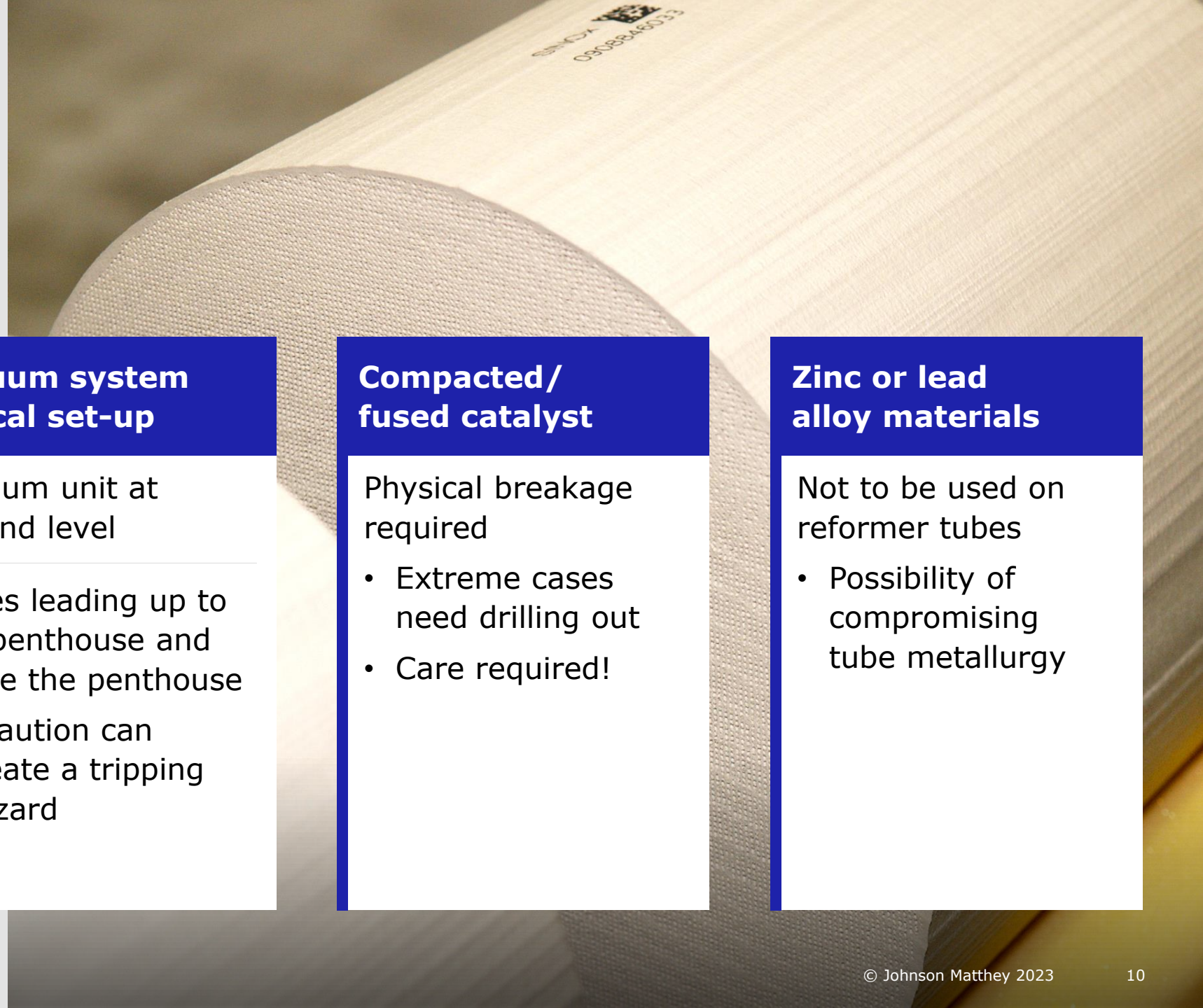
## Steam reformer

# 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

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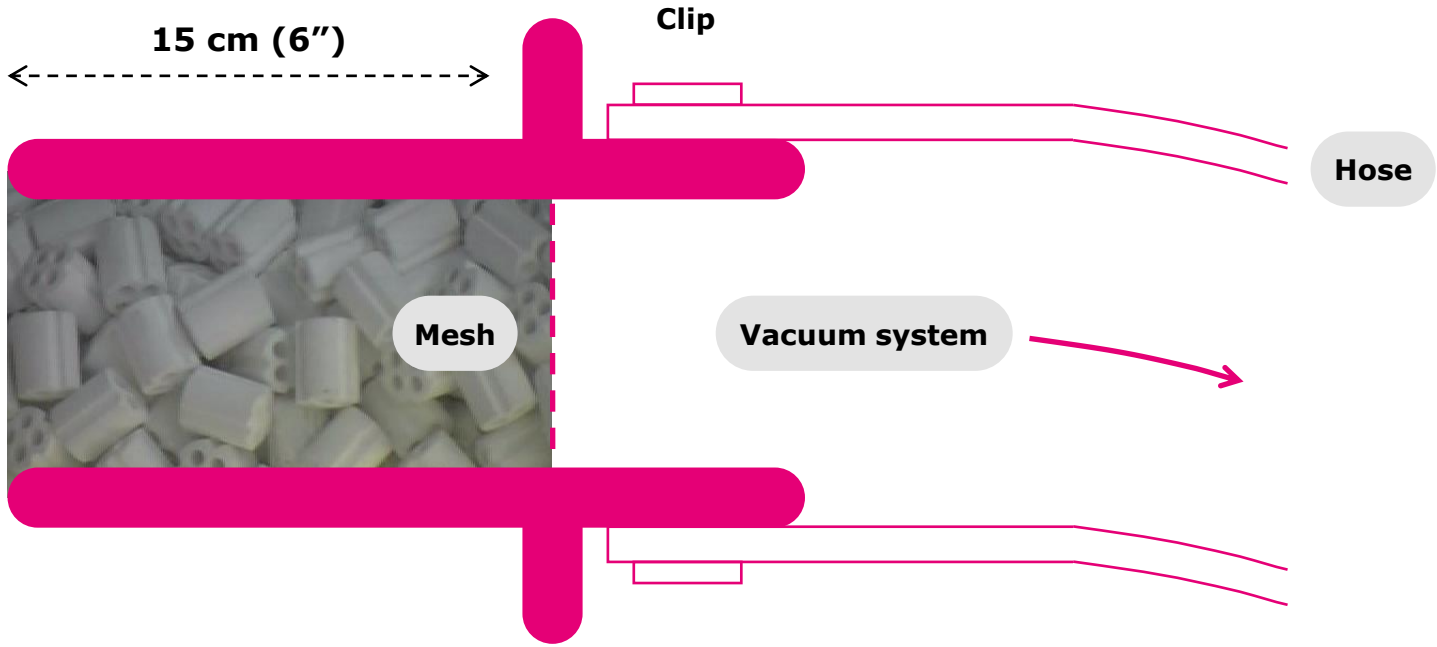
# Steam reformer – catalyst sampling

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



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## Steam reformer

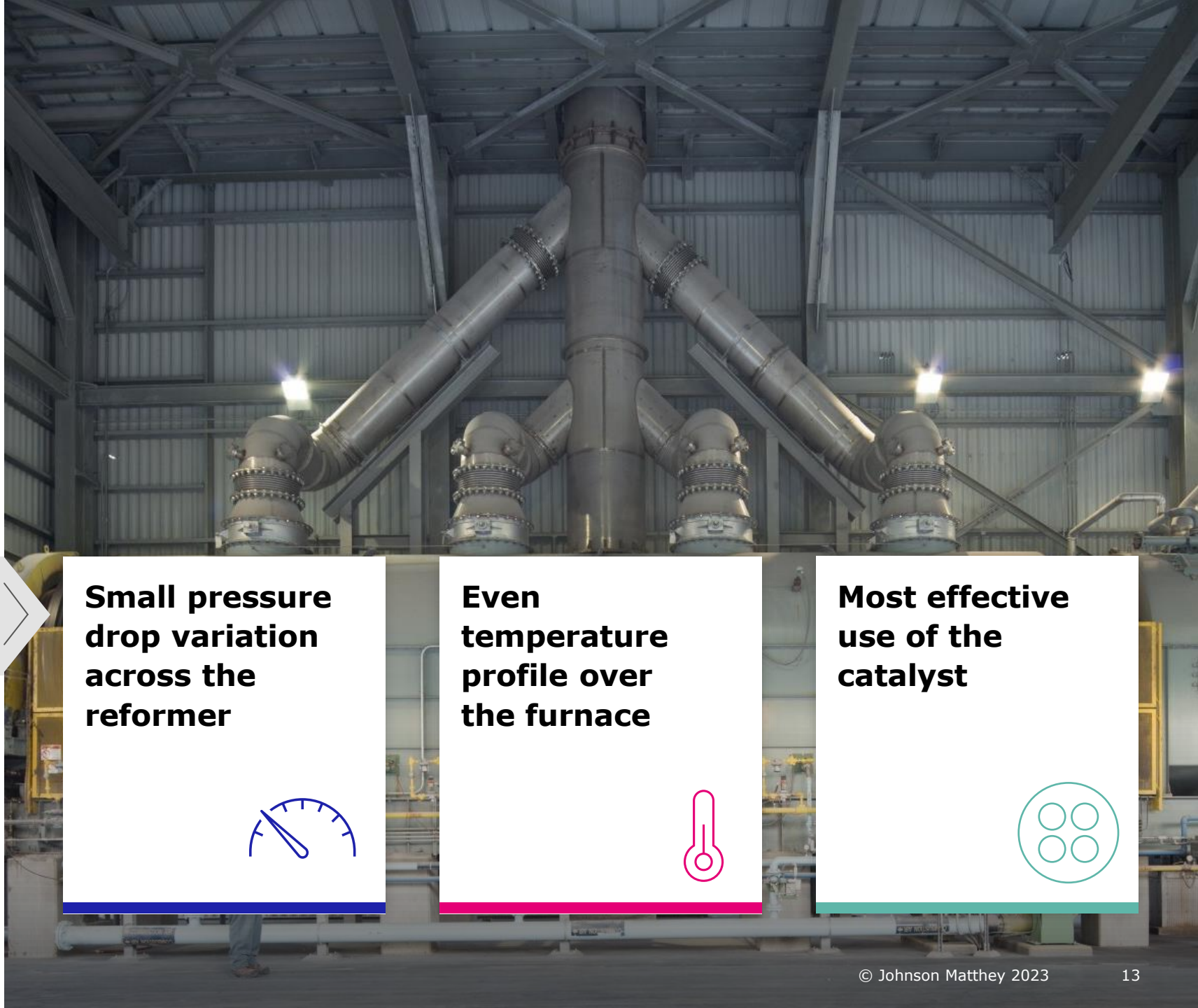
# Steam reformer – loading objectives

**Loading ideally aims to achieve:**

Uniform catalyst packing in every tube to give

- Uniform gas flow throughout the Reformer

**Resulting in**



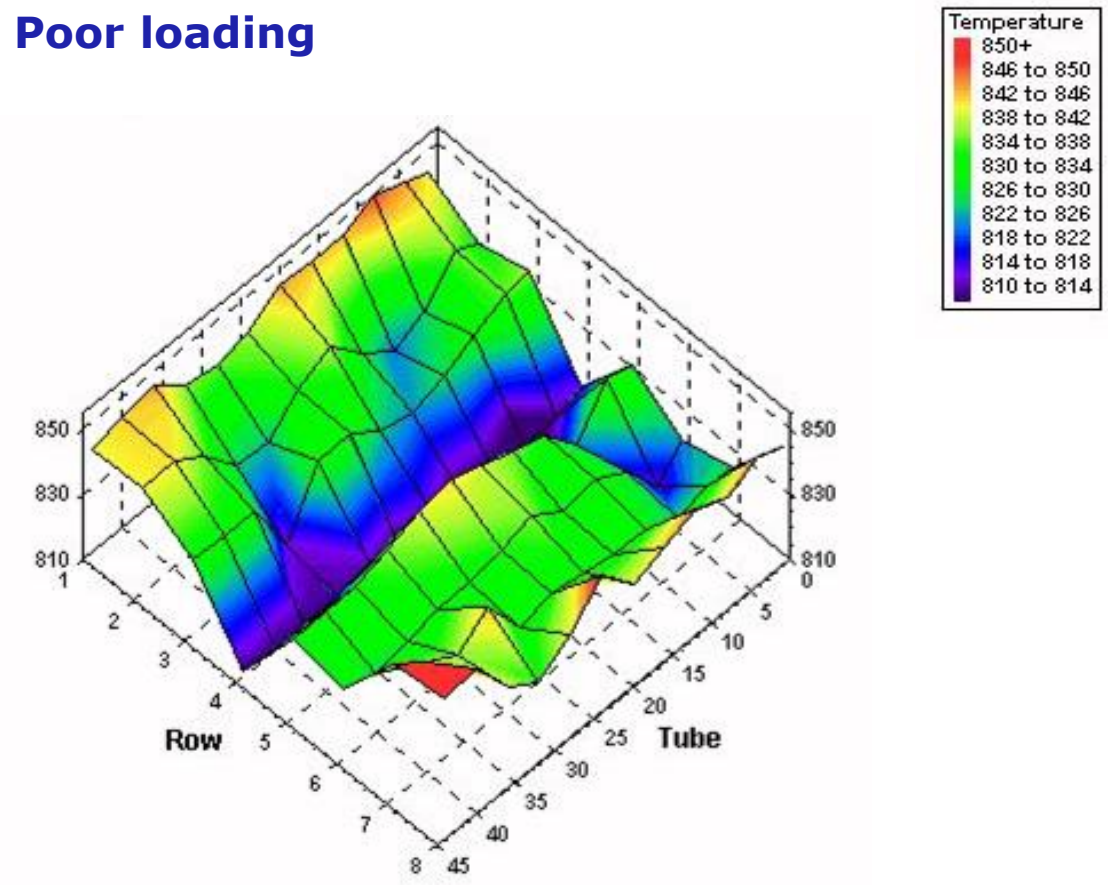
**Small pressure drop variation across the reformer**

**Even temperature profile over the furnace**

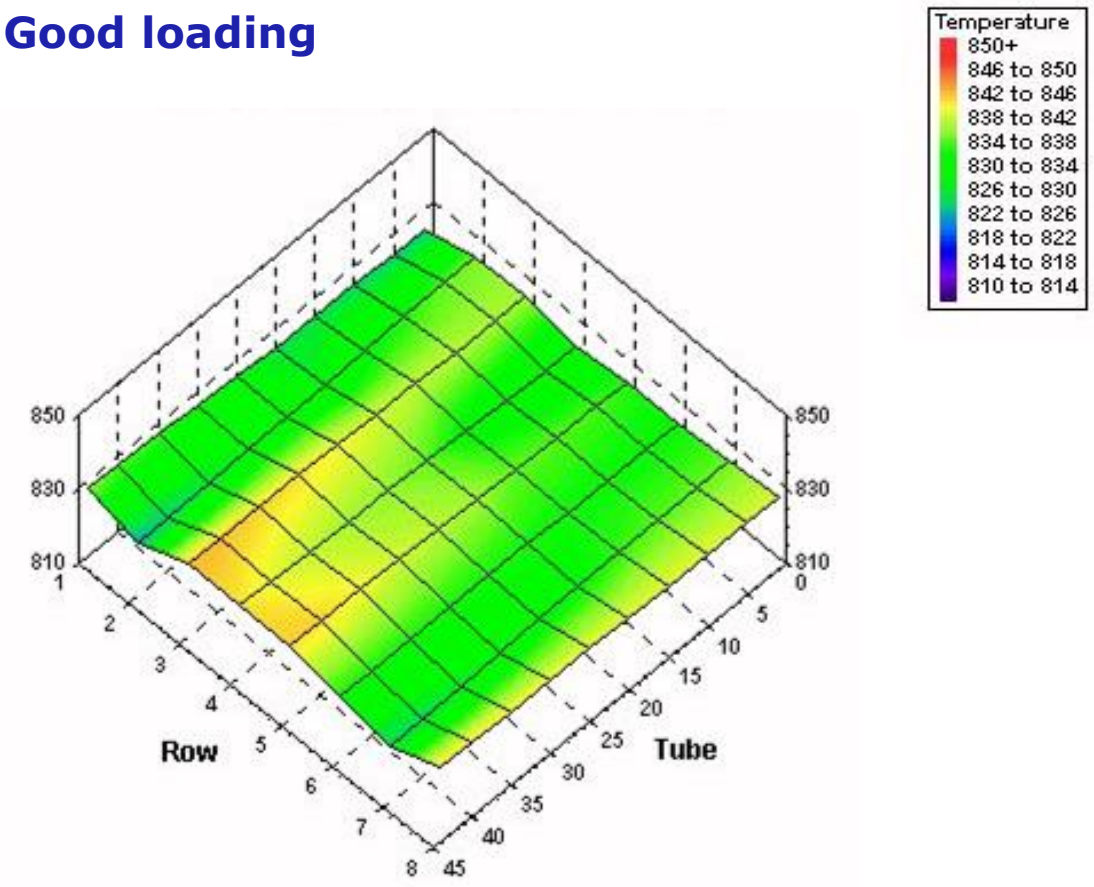
**Most effective use of the catalyst**

# Steam reformer – loading objectives

## Poor loading

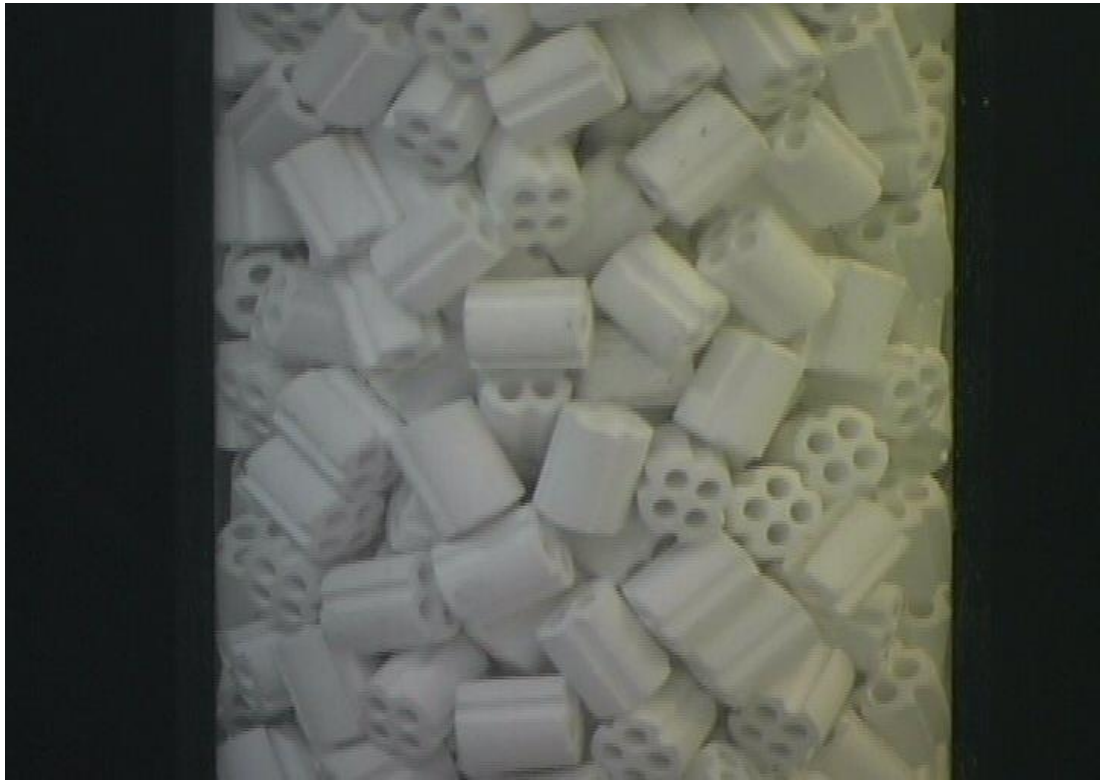



## Good loading

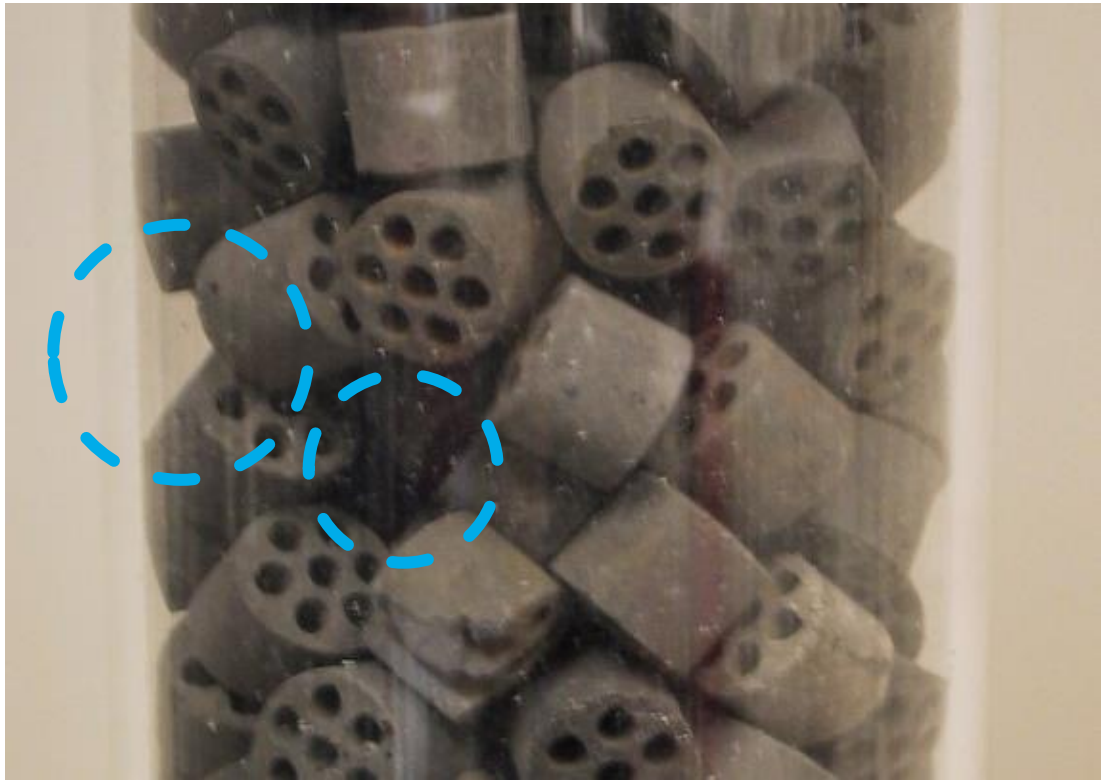


# Steam reformer – loading objectives

## 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

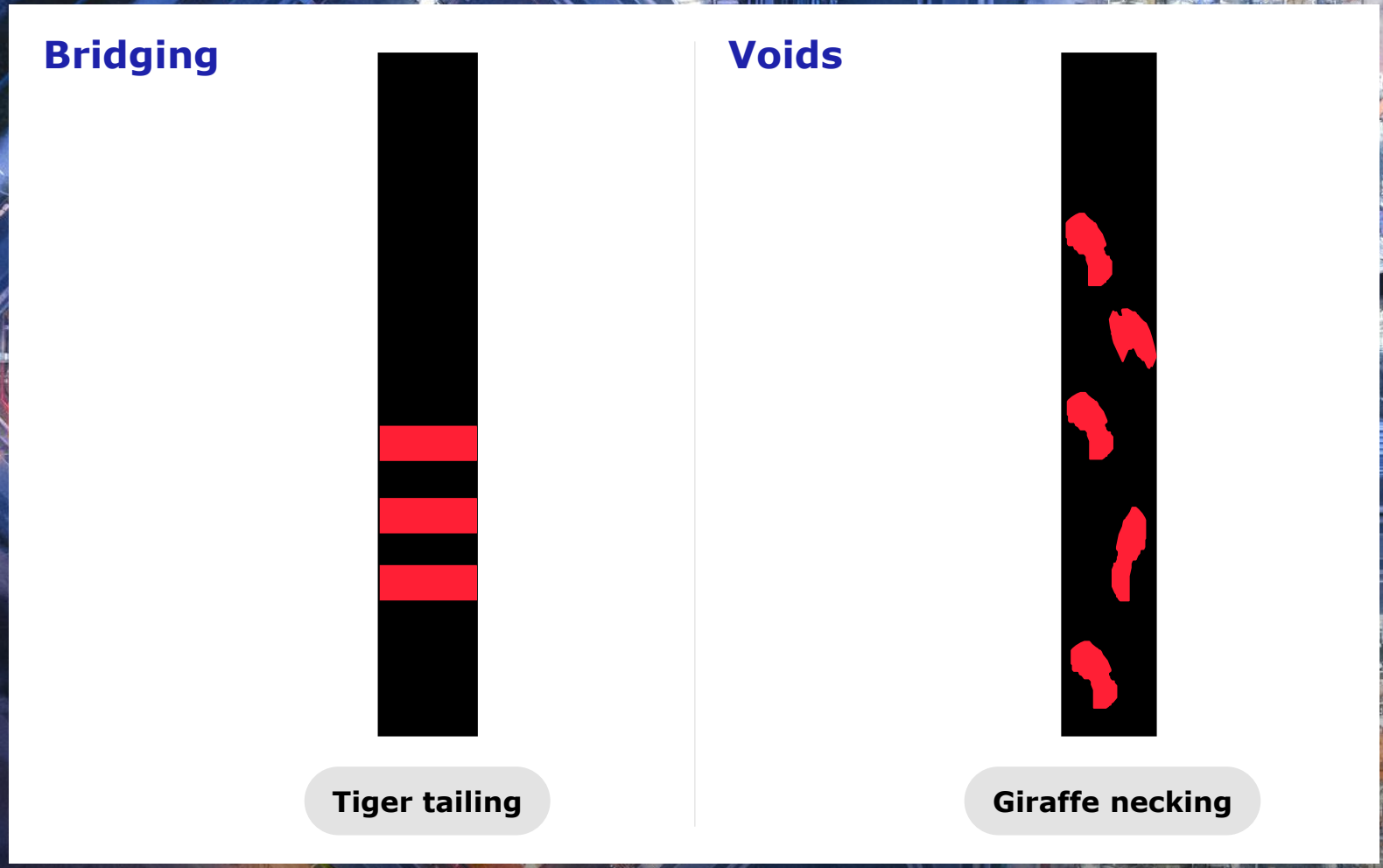
**Occurrence influenced by**

Catalyst shape and size

Miscare with loading

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

Large voids are worse

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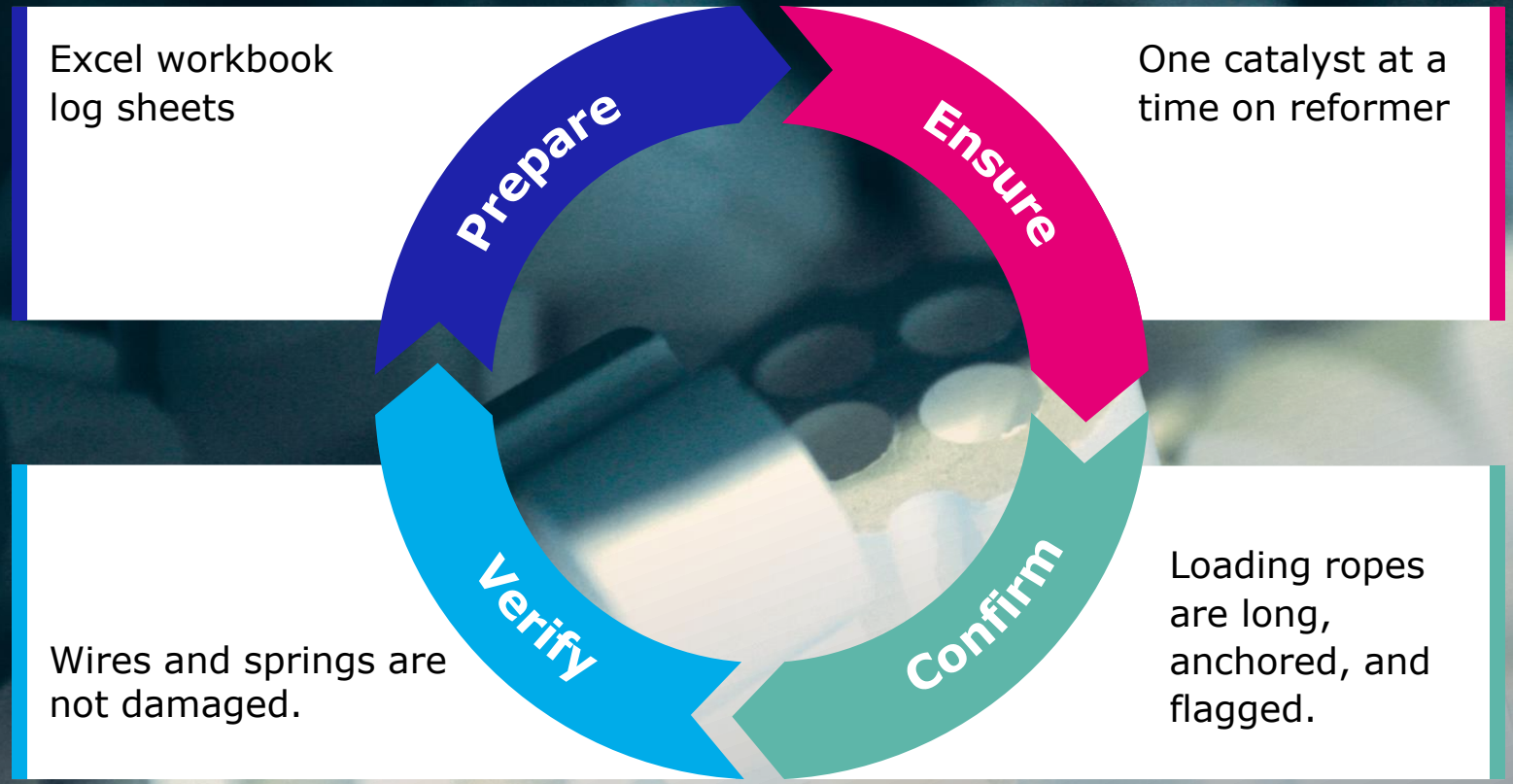
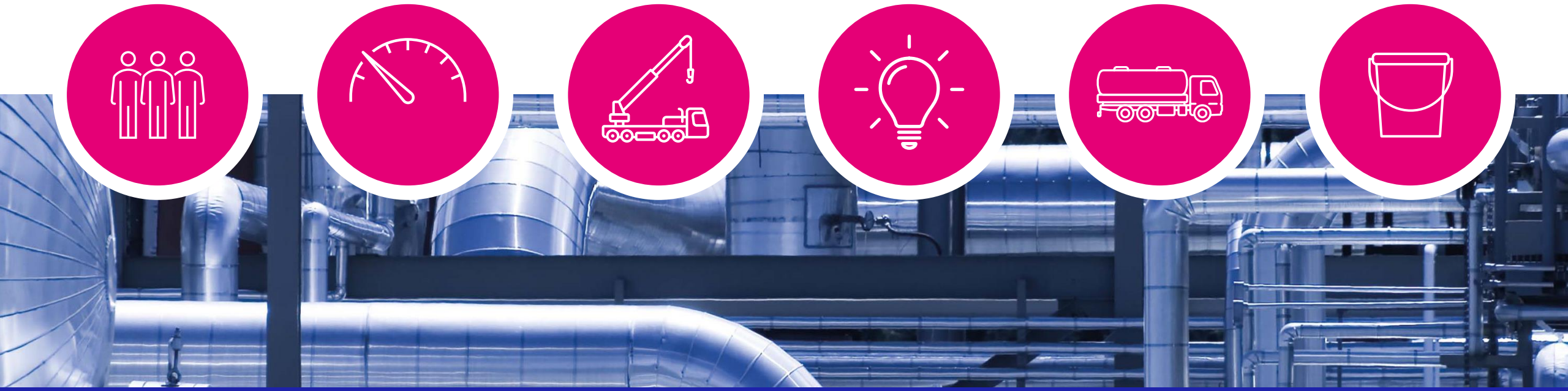
## Steam reformer

# Steam reformer – pre-loading principles



# Loading principles – facilities required

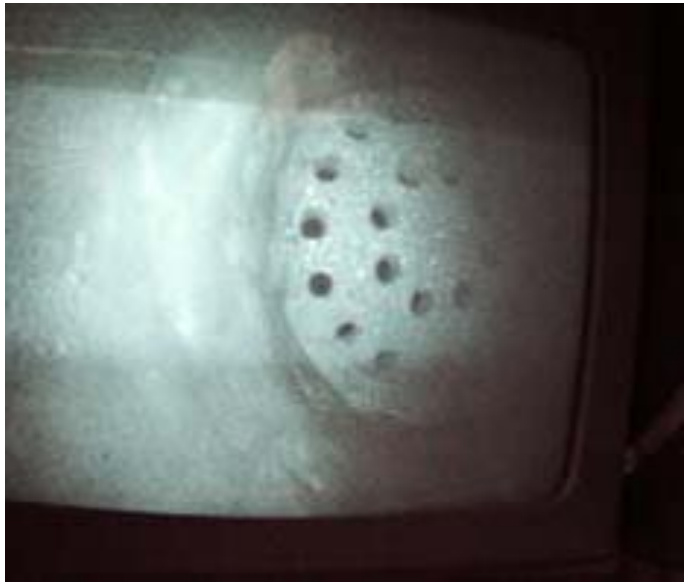


# Loading principles – empty tube inspection

**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**

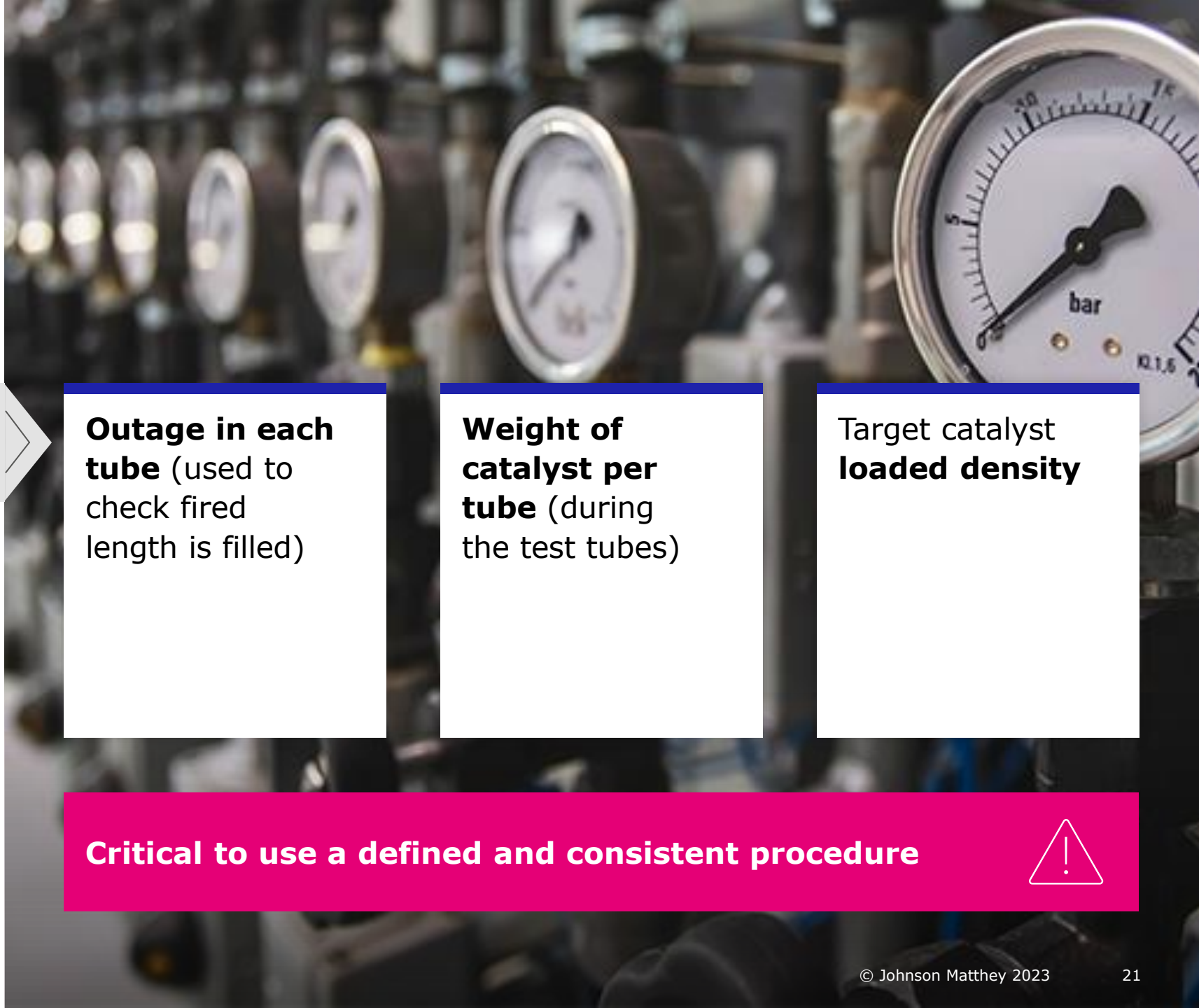
**Important information to review is:**

**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**

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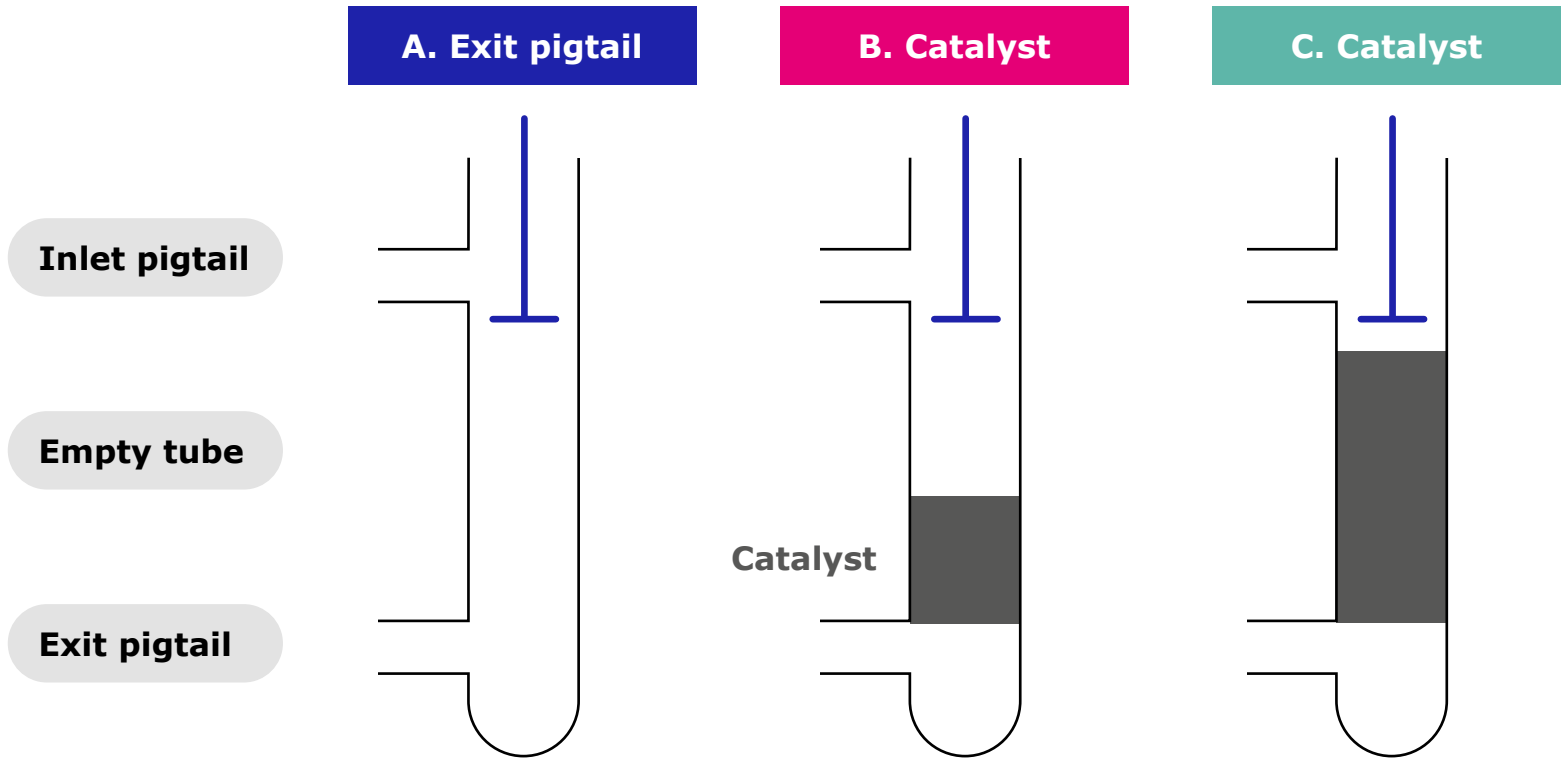
# Loading principles – dP procedures

## dP measurement critical to success - 3 steps




Stage A **confirm pigtails are clear**

Stage B **is used if two or more types of catalyst**

# 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<br>• 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

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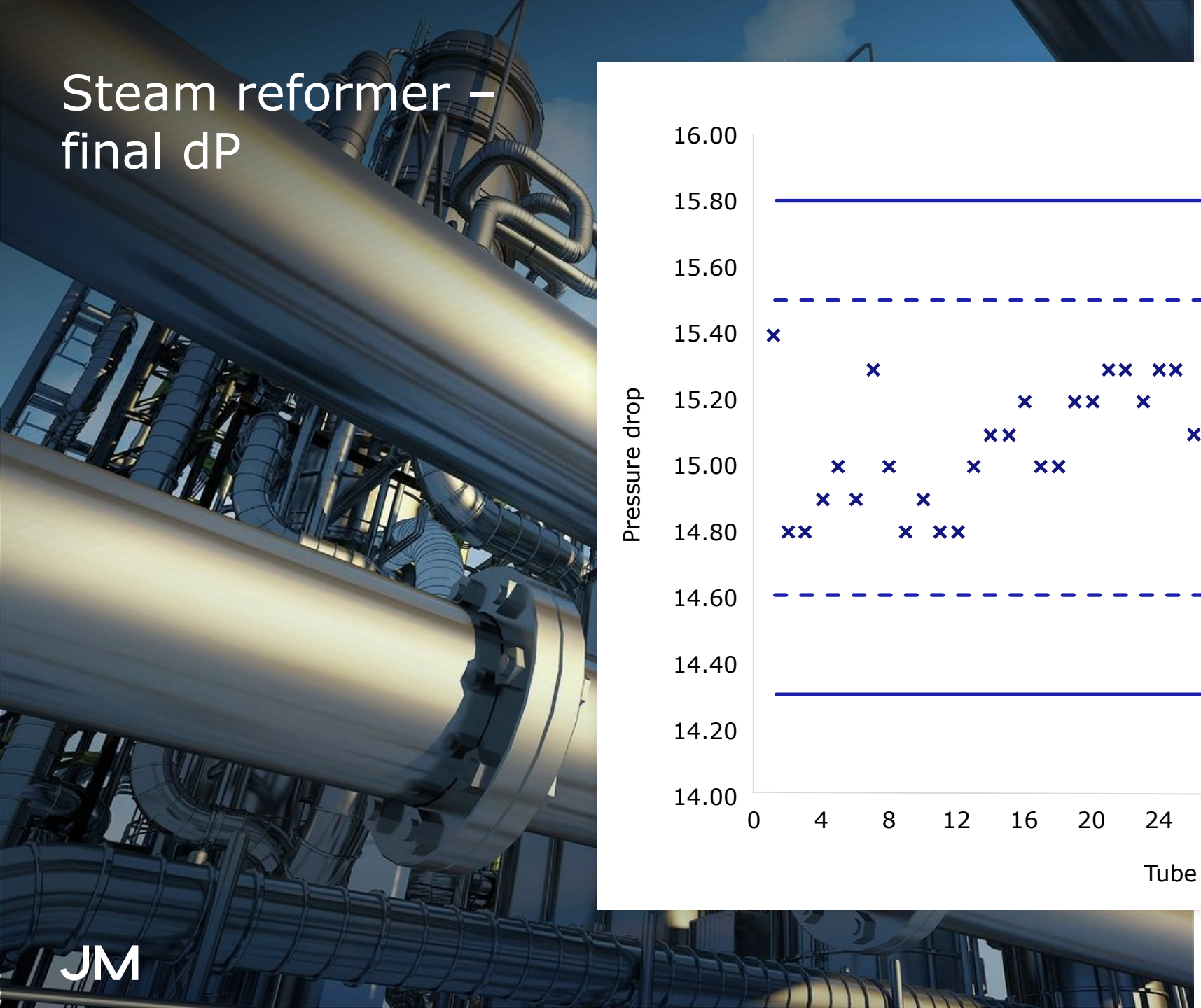
# Steam reformer – final dP



# 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

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## Steam reformer

# Steam reformer – measure of dP

## dP measurement principles

**Provide fixed air flow**

(Choked flow through orifice)

**Mass flow rate through orifice function of**

Upstream pressure (known)

Orifice diameter (known)

Temperature (known)

**Downstream pressure is measure of dP**

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## 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

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# Steam reformer – loading techniques

## Dense method

**Uses device to break catalyst free fall in tubes**

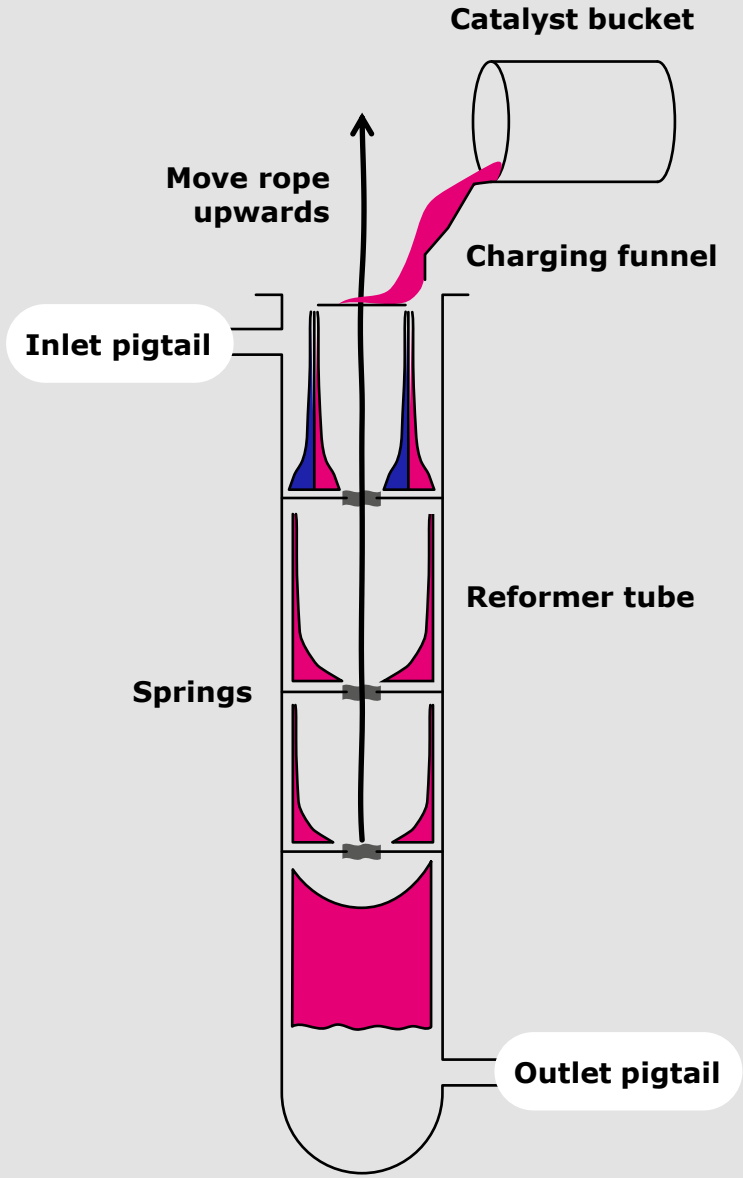
Springs on spiral

Knotted line

Discs

Brushes

**Raise rope as tube fills**

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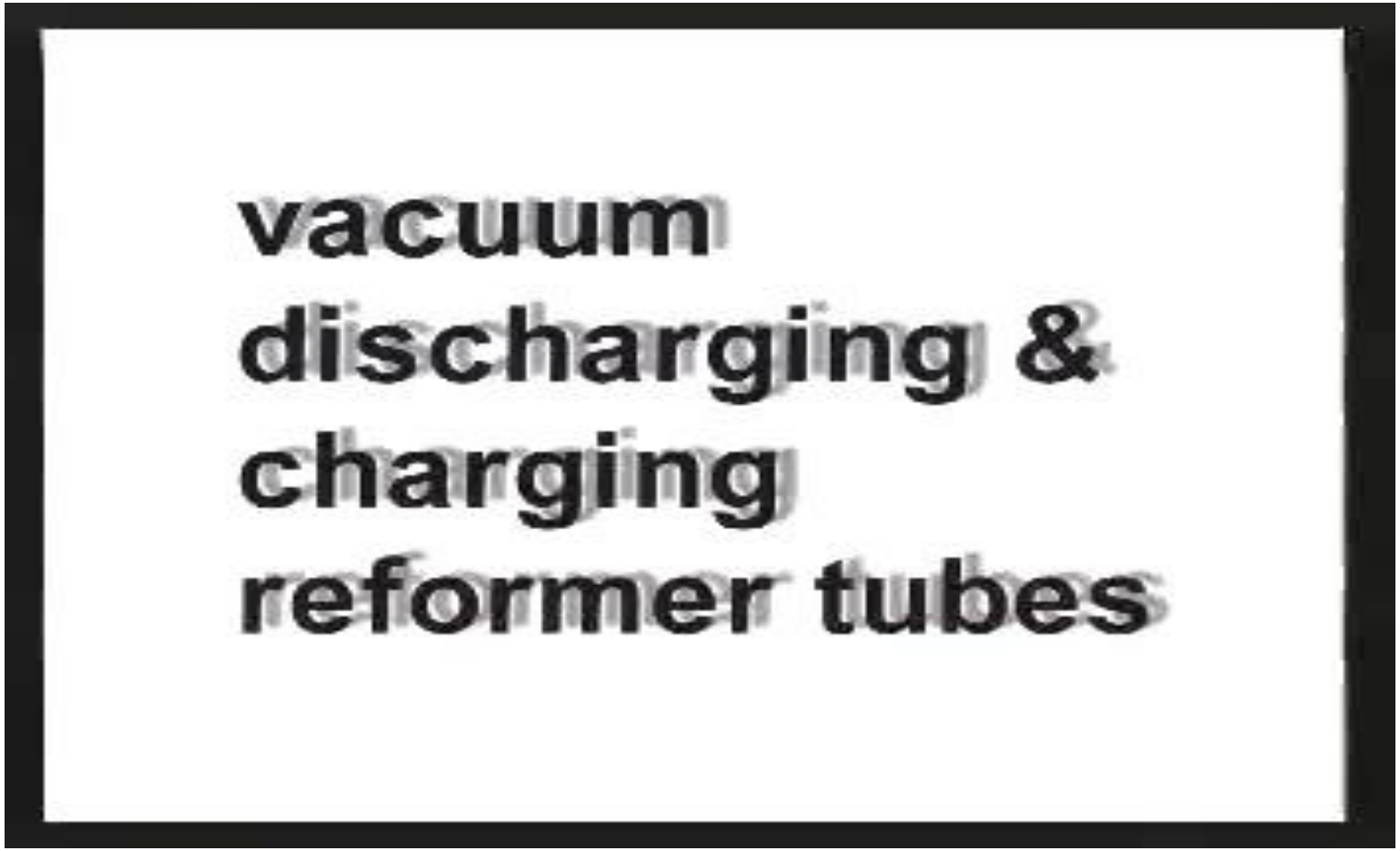
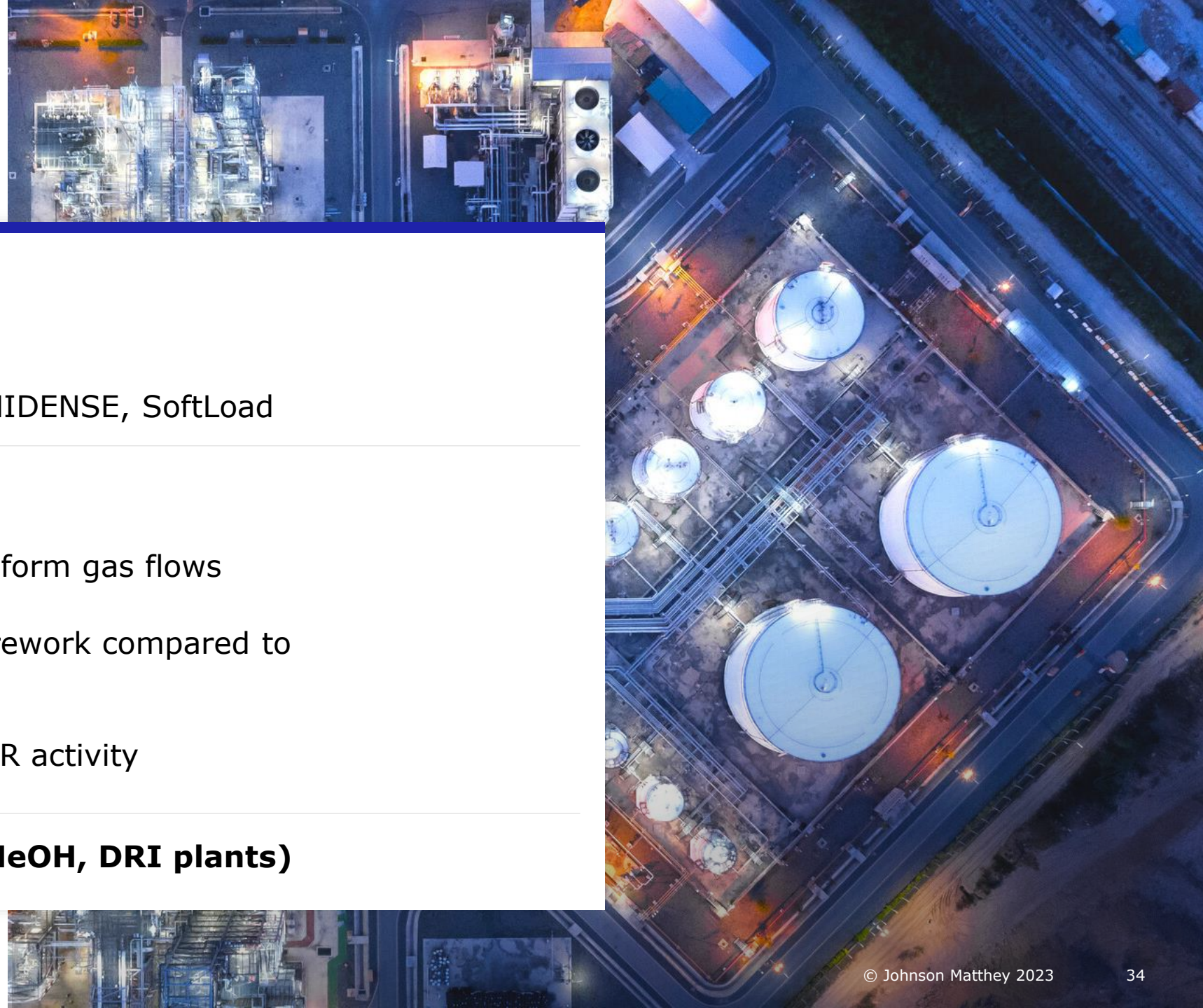
# Steam reformer – loading techniques

**Dense method**



# 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)**

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## 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**


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