The Basics of Pickling a New Natural Gas Pipeline

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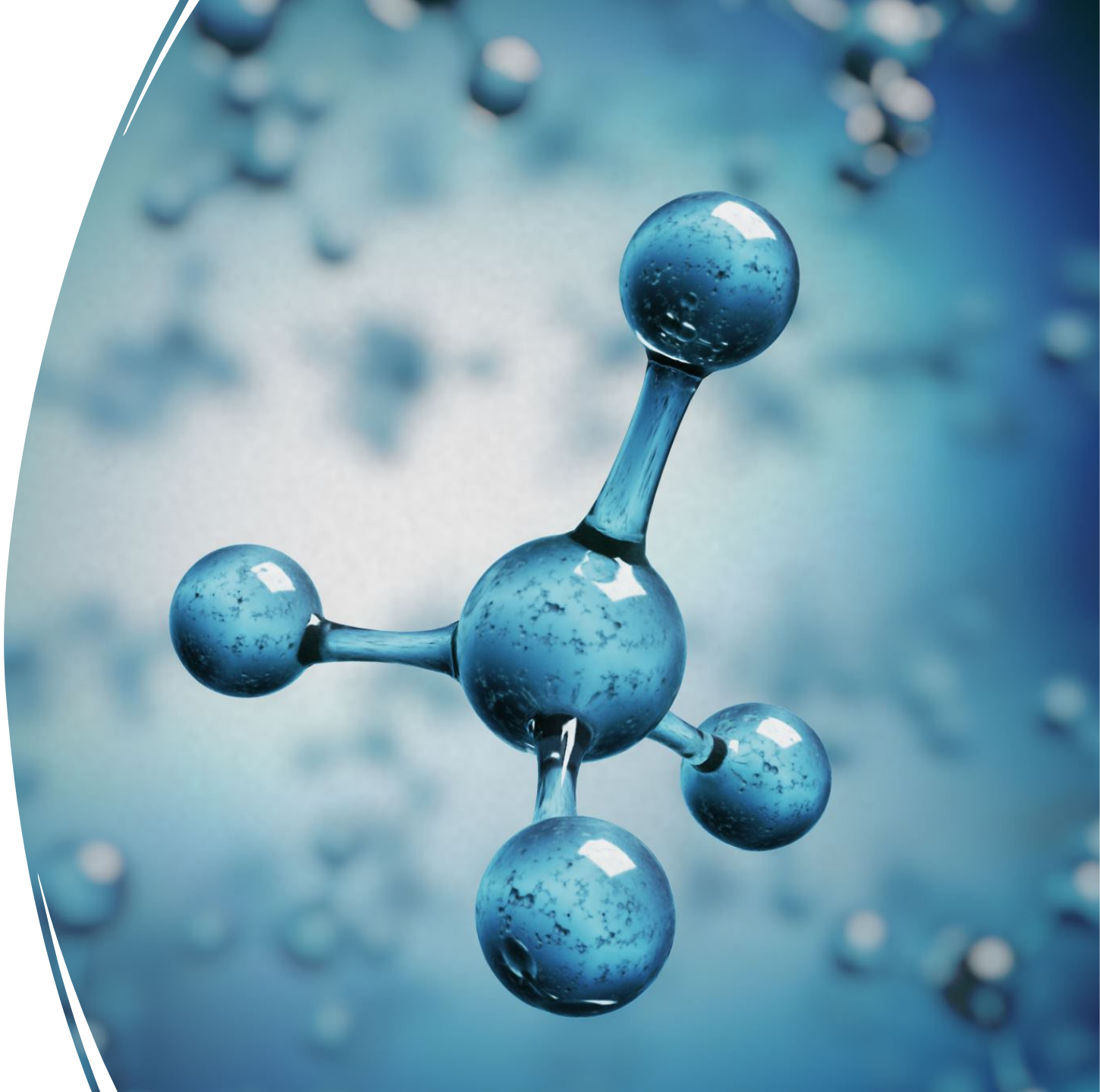
Agenda

- Introductions/Overview
- Parameters of pickling
- Pickling Considerations
- High peak demand project case study
- Considering pickling during pipeline design
- HSE/Minimize emissions
- Large Scale Pickling Projects

Why do we odorize natural gas?

- In natural state, natural gas is colorless and odorless
- Odorant is added to give a pungent smell to easily detect fugitive natural gas.
- Ensure safe transport and delivery of natural gas



Odorization Regulation/Standard

- Federal Regulation 49 CFR Part 192.625
  - CFR states natural gas in a distribution line must be odorized to a level easily detected by a human's olfactory senses
  - Odor concentrations between .1-1 ppb are easily detected
  - Operators are required to conduct periodic sampling to ensure pipelines are in compliance

Odor Fade - Reaction

When a new natural gas pipe is installed, the porous inner wall of the pipe contains metal oxides which will react with odorant to produce disulfides

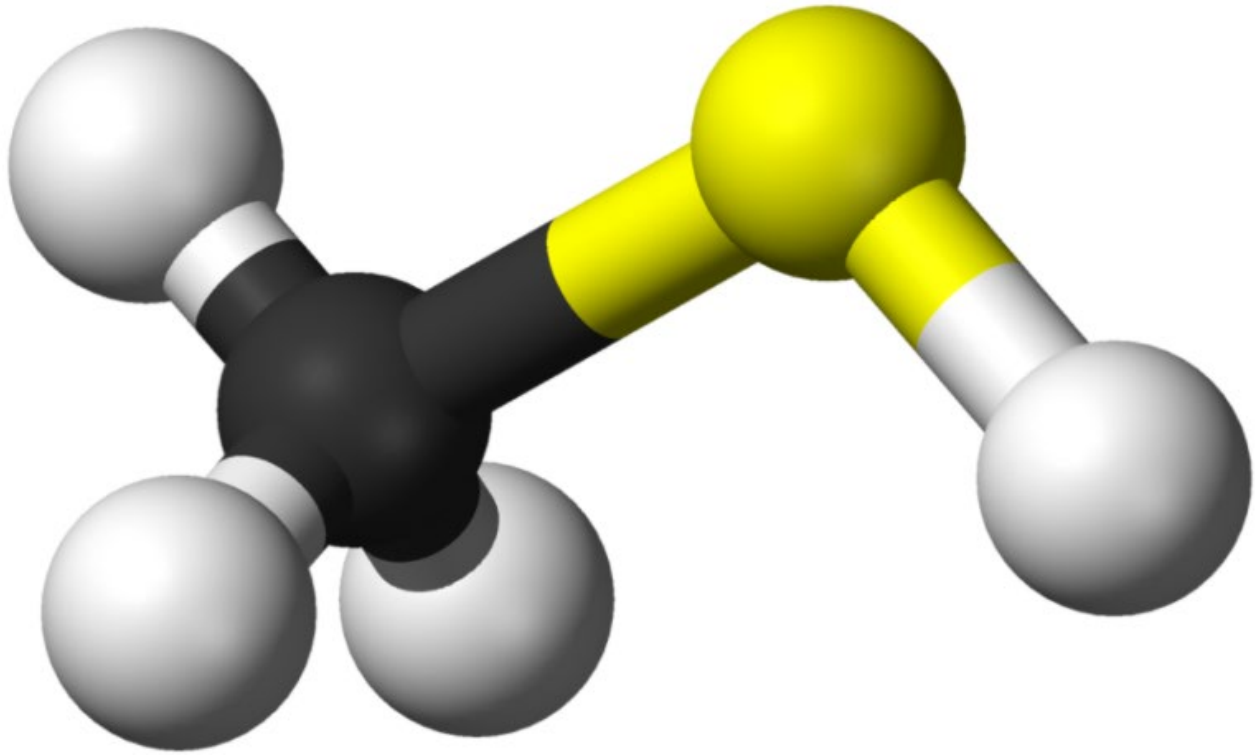
Disulfides have a much lower odor potency than injected odor

This leads to much lower odorized/not odorized gas leaving the new section of pipe

This process will continue until the entirety of the ferric oxide of the new pipe reacts with odorant

Odor Fade - Adsorption

- The porous inner wall of the pipe has an affinity for odorant causing odorant molecules to be adsorbed to the pipe walls
- Gas velocity is inversely proportional to adsorption rate
- Adsorption plays a much larger role in pickling of lower flow rate projects



Methyl Mercaptan Molecule

Intro to Pickling/Conditioning

Pickling is the process of using temporary odorizers to combat odor fade and rapidly expose new pipe to odorant

Pickling aims to achieve odorant saturation of newly installed pipe to expedite reactions with ferric oxide

When pipeline has been pickled, odor fade process is significantly reduced allowing return to normal operations

Methods of Pickling

Pickling

- Static Pickling
  - Odorant is injected while pipeline is being packed to operating pressure
  - Speeds up the breakthrough process
  - Not a feasible method for fully pickling a new section of pipe or when replacing existing line

Pickling

- Dynamic Pickling
  - Odorant is injected while pipeline is in operation
  - This represents the vast majority of pickling projects

Parameters of Pickling

- Setup of project
- Pipeline pressure
- Flow rate profile/gas velocity window
- Odorant type/Material
- Cleanliness/liquid free

Setup of project

- Pickling included in the design phase of project
- Determining number and location of odorization injection and sampling points
- Does the pipeline have any Laterals?
- Understanding elevation profile of the pipeline
- Time of year the pipeline is being brought into service

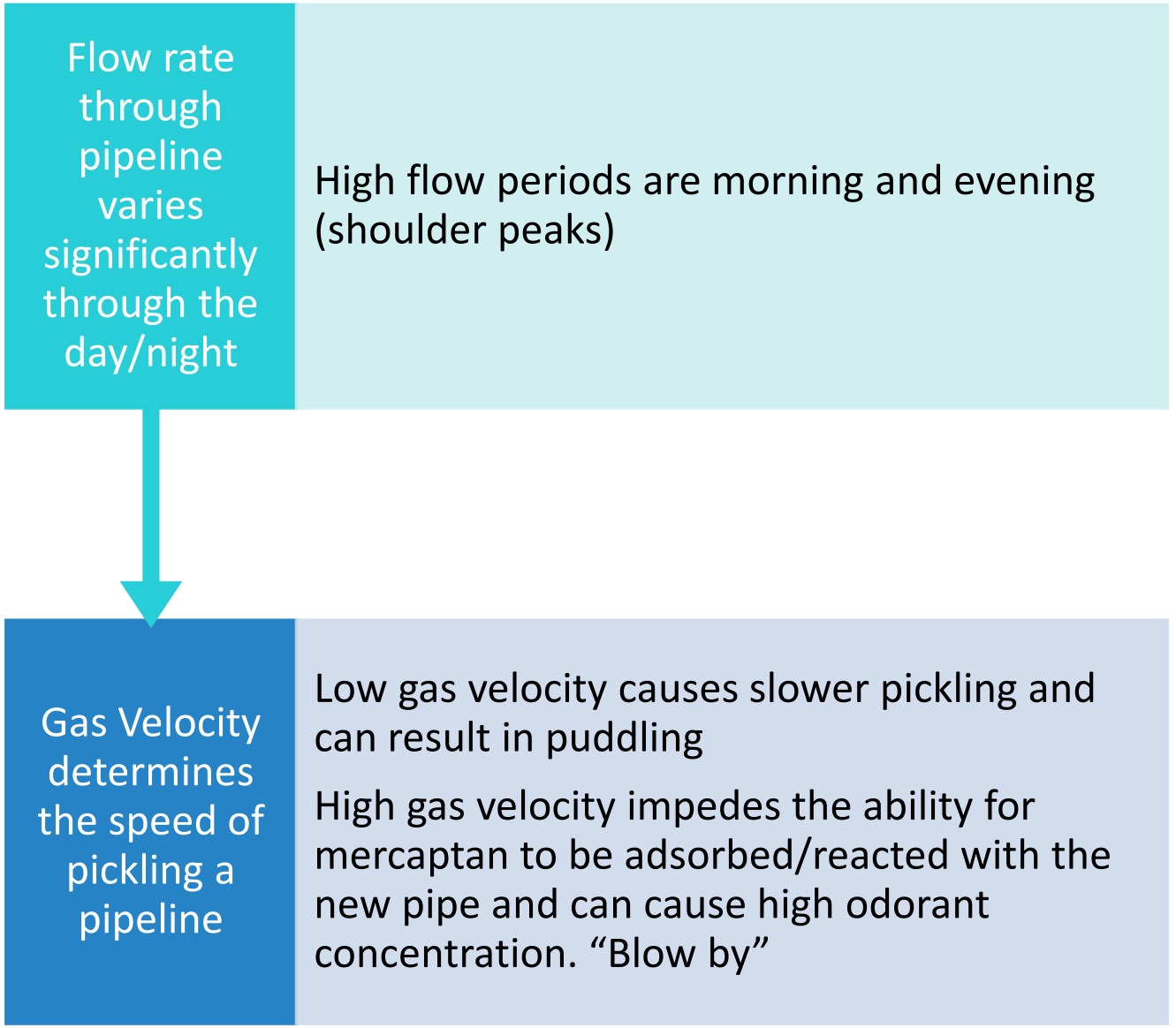
Pipeline pressure

Pressure plays a large role in amount of odorant required

- Higher pressure requires more odorant
- Adsorption vs reaction

Low pressure (<100 psi) does not allow for the use of flow-meter and may cause problems with instrument gas

Flow rate profile/gas velocity window



Odorant Type

Scentinel E and S-20

- More reactive

T-50

- Thiophane (50%) is significantly less reactive

Pipeline needs to be clean of rust, liquids, and debris

Recommended swab pig penetration 1/8”

Pipeline Cleanliness

Pickling Considerations

- High peak demand project case study
- Considering pickling during pipeline design
- HSE/Minimize emissions
- Large Scale Pickling Projects

Some projects have a single industrial consumer which accounts for the majority of flow

This requires us to turn off units during the very high flow times until velocities return to normal

High velocities do not allow for sufficient adsorption/reaction	This can cause odorant blow-by which could lead to high odorant concentration for consumers

Peak **Demand** Project Case Study

Considering Pickling during Pipeline Design

- Helpful to consider pickling during engineering design of pipelines
  - Injection Points
    - Prefer to inject directly into pipeline if possible vs dog legs
  - Sampling Points
    - Consistent flow makes sampling and flow modulation more consistent
    - Prefer to take samples as close to end of pipeline as possible
  - Time of year
    - Fall and Spring are ideal times for pickling
    - Summer takes longer – low flow
    - Winter – very high flow – blow by without adsorb or reaction

HSE/Minimize emissions

Dynamic pickling minimizes emissions compared to historic venting or flaring practices

Supplying on-site personnel during pickling process ensures safety and execution of the project

Large Scale Pickling Projects

Extremely long runs of pipe (>20 miles) can cause operational issues

Multiple units injecting odorant requires large capacity requirement

Pickling monitoring becomes difficult due to travel time

Mobilizing a second pickling crew can mitigate problem

Large Diameter vs Small Diameter Pipe

We currently are comparing large diameter pipe -16, 20, 24 to

Small diameter pipe 12 inch and smaller

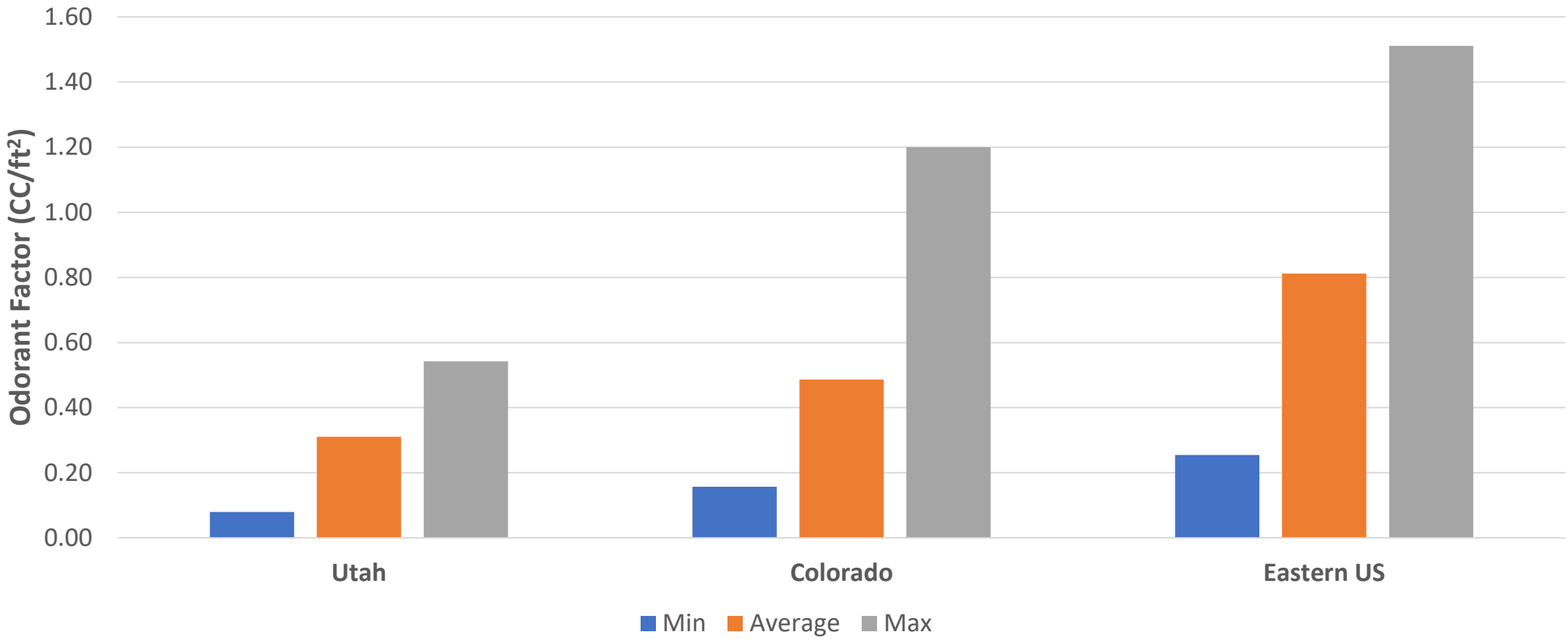
Preliminary data larger diameter = larger pickle factors

In some projects 20% greater

Regional Odorant Factor Analyses

- We pickle in three distinct regions of the US
- We evaluated projects in three geographical regions of the us for pickling dosage req.
- Utah region includes, UT, WY, AZ
- Colorado was just Colorado
- East US includes Carolinas, MI and TN
- We saw significantly different odorant pickling factors based on the regions

Odorant Factor by Area Summary



Odorant Factor by Area Data