EXPERTS IN FLUID ENGINEERING

The Art of Mixing, Anaerobic Digesters

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Aims

- Highlight the importance of getting digester mixing right

- Provide an overview of the current state of the art in digester mixing

Contents

- Importance of digester mixing
- Mixing objectives and design criteria
- Measuring and modelling mixing performance
- Digester mixing state of the art
- Digester and Sludge Mixing Software

Background

- Increasing number of digesters, mixing and holding tanks are in use
- Wide range of mixer types/sizes
- Few mixing criteria established or applied
- Reliance on mixer suppliers, no independent design information
- No link between rheology and mixer sizing
- Variable “success” of installed mixers

Industry Needs

- Why is mixing so increasingly important?
  - Thicker feed sludges to improve throughput, leading to thicker digestate
  - Smooth out variability in feed physical properties
  - Maximise gas production
  - Maintain uniform digester temperature
  - Avoid built-up deposits on digester floor
  - Dilute inhibitory substances entering digester
  - Avoid short circuiting to maximise pathogen kill

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Mixing Objectives

- What should the mixer achieve?
  - Blending feed sludge into the bulk
  - Generate the desired flow pattern
  - Minimise dead or stagnant zones
  - Avoid solids accumulation
  - Scum drawdown
  - Enable tank emptying

Defining Mixing Criteria

- Feed Slurry Blending
  - Blend Time: time taken to achieve a predetermined degree of concentration homogeneity
  - 90% blend time: the time taken for concentration fluctuation to be within +/- 10% of the mean concentration
  - Typically, 90% or 95% blend times of 1 to 2 hours are specified for digesters
- Active volume
  - The 'non stagnant' volume
  - Typically, 90% or 95% specified
- Extend of short circuiting

Modelling Performance

- Published Design Information
  - Digester mixer design
  - Chemical process mixer design
- Physical Modelling
  - Clear simulants for slurry & feed
  - Velocity and blend time measurements
  - Wash out curves
- Computational Fluid Dynamics
  - Flow patterns, velocities and blending

Digester Mixer Design Consideration

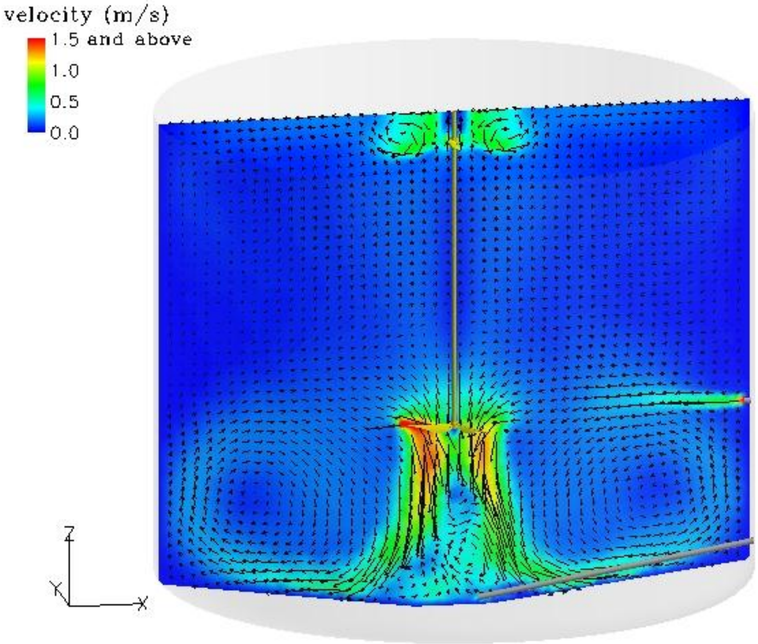
- Digester shape (base & aspect ratio)
- Feed & digestate rheology
- Location of inlets & outlets
- Digester feed rate & cycle
- Digester flow pattern & residence time
- Mixer type and size

State of the Art

- Feed location

State of the Art

- Impellers



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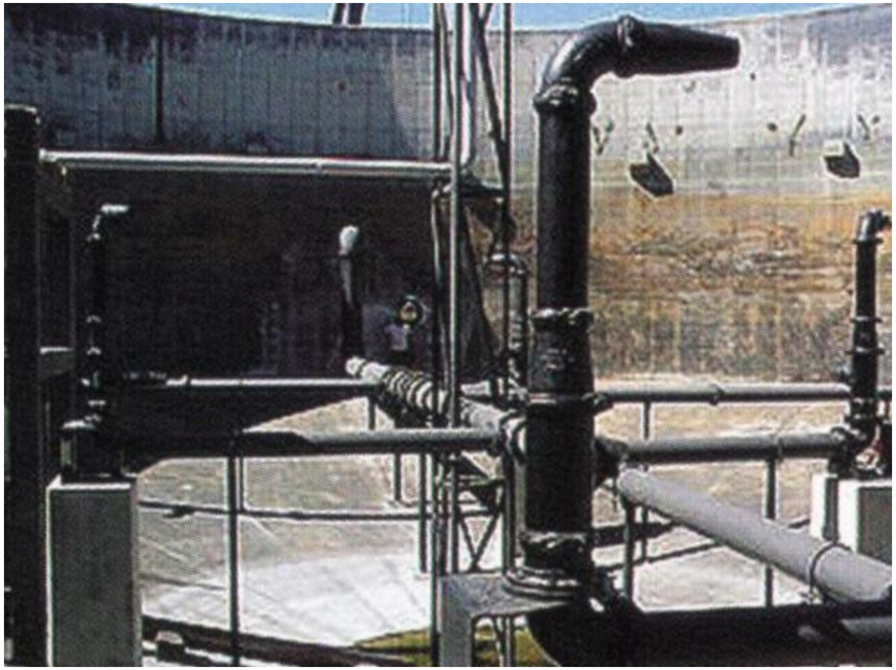
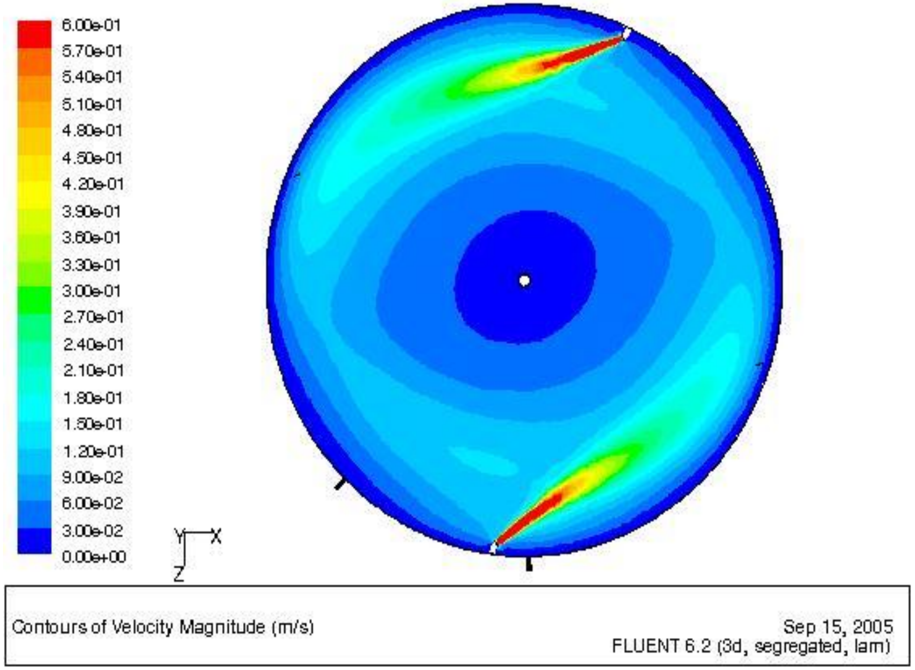
State of the Art

- Jets

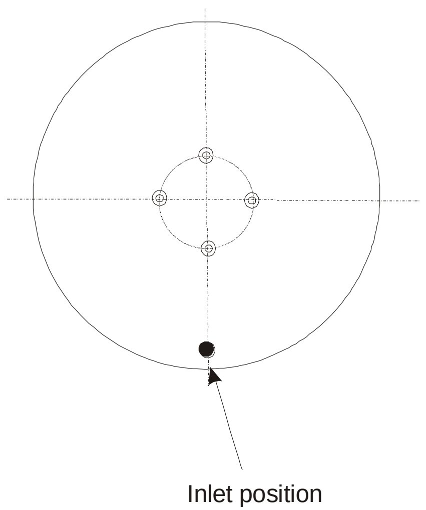




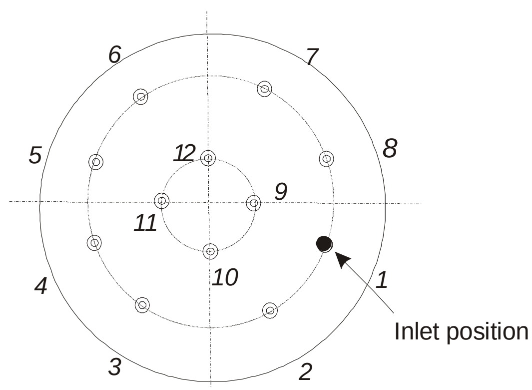
State of the Art

- Unconfined Gas
  - Continuous or sequential gas addition through the nozzles
    - No difference for low viscosity digestate
    - Sequential superior for high viscosity digestate

(a) Sparger A



(b) Sparger B



WWM Scope for Digester Mixing

- CR8239 Sludge Tank & Digester Mixing Research Report
- CR8237 Digester & Sludge Tank Mixing Design Guide
  - Mixer design, rating, and selection guide
  - Linked to performance criteria
  - Sludge rheology dependent
  - Based on physical modelling and CFD

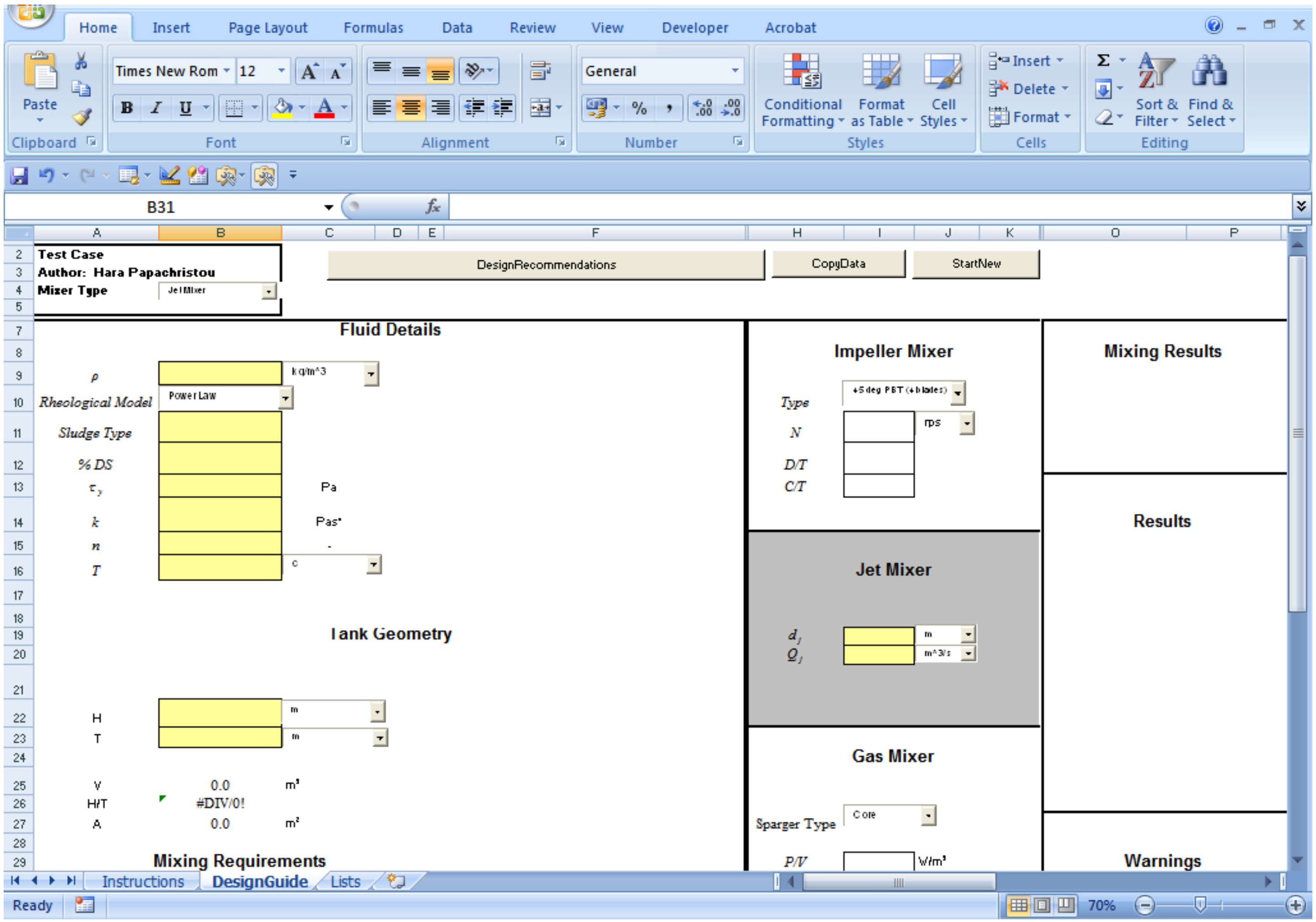
Digester & Sludge Tank Mixing Software

- Aims:
  - Enable easier and practical application of the paper design guidelines
  - Allow range of mixing scenarios based on combinations of different tank geometries, sludge properties, mixer type
  - Allow rating of digester mixing performance

Digester & Sludge Tank Mixer Software

- Excel based software
  - Non newtonian fluids (Power Law and Herschel Bulkley)
  - Transitional and turbulent regimes
  - Jet and submersible mixers
  - Impeller mixers (focus on axial impellers)
  - Unconfined gas mixers
  - Two primary criteria
    - Blend time
    - Active or cavern volume calculations

Digester & Sludge Tank Mixer Software



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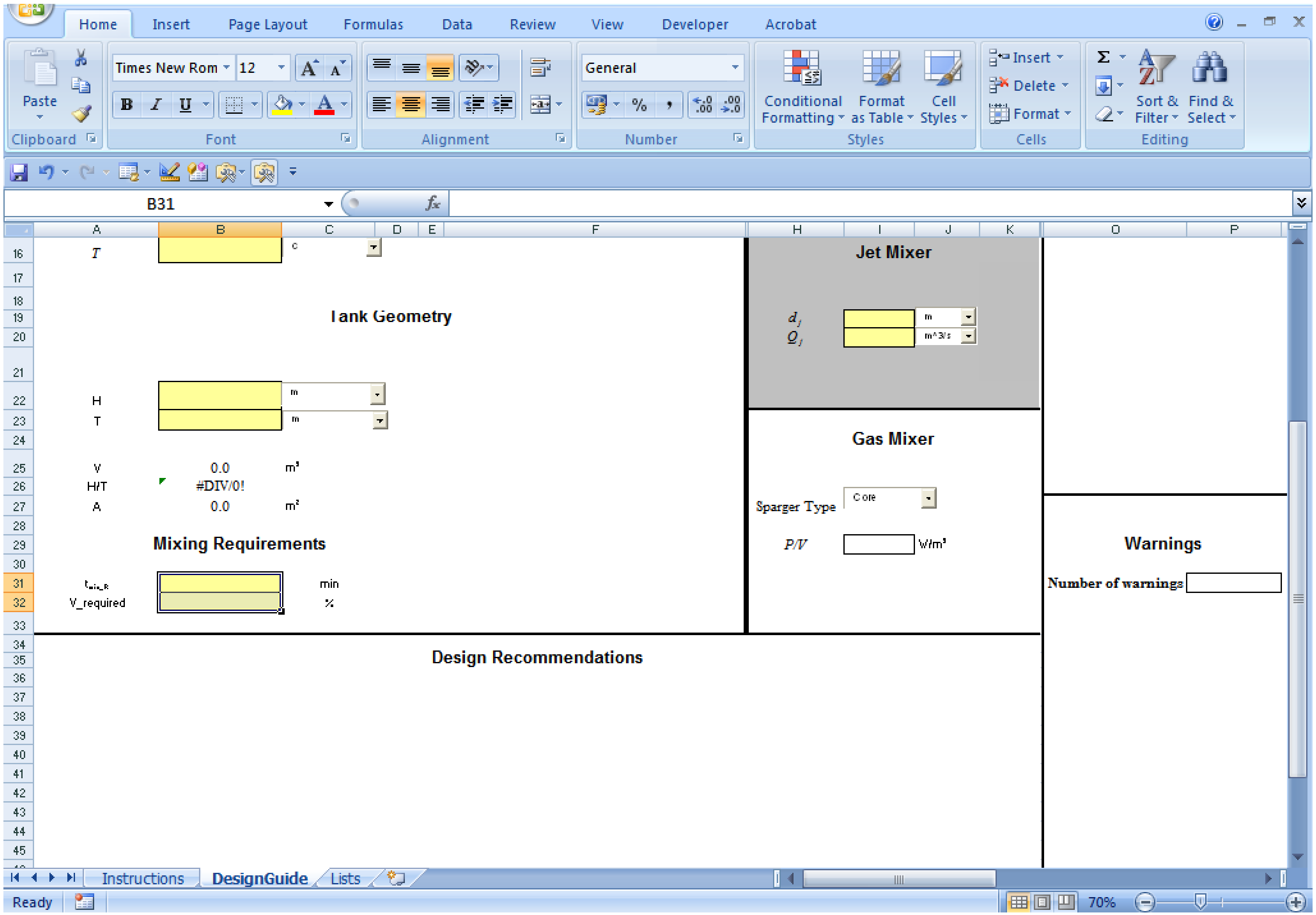
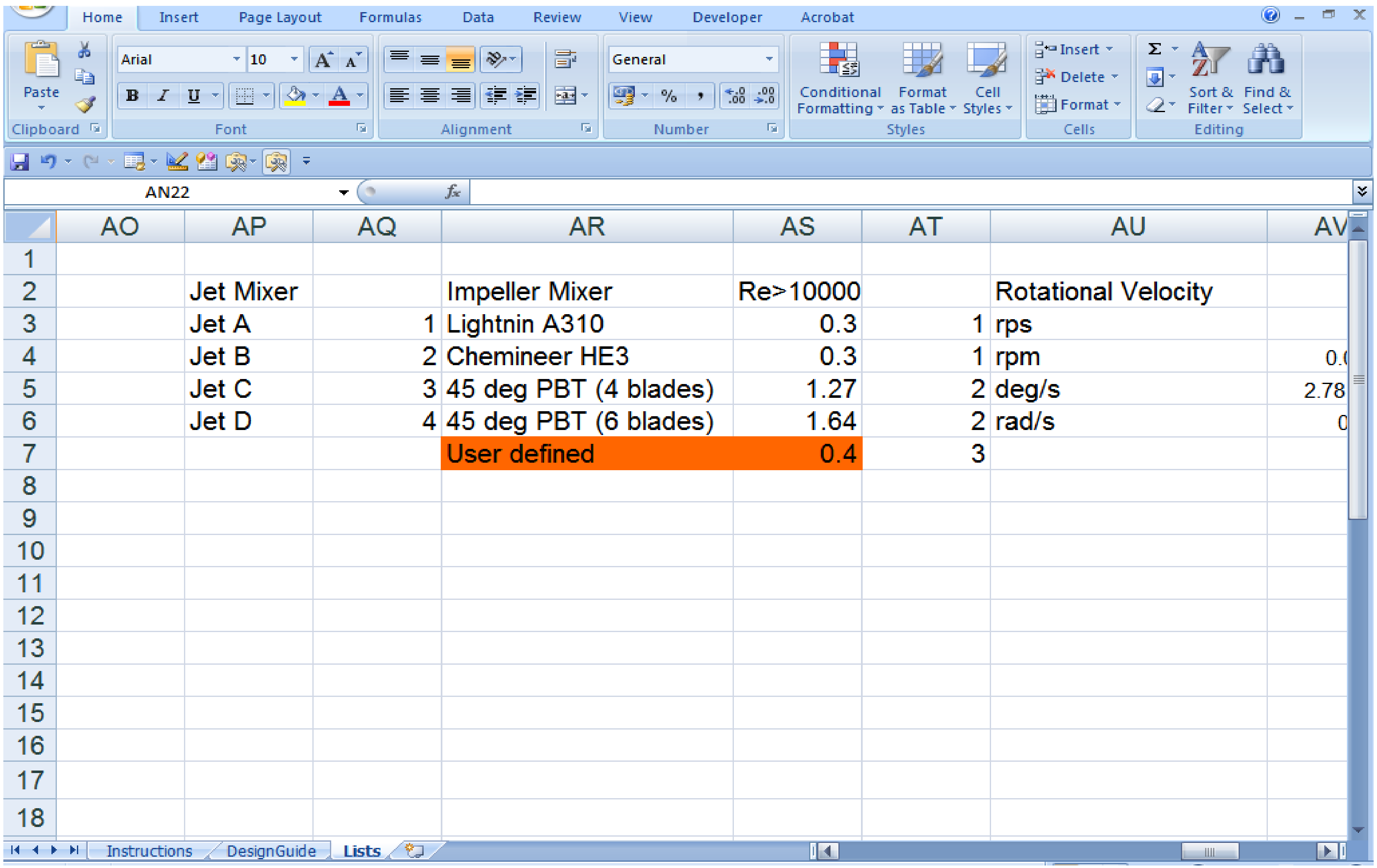
Digester & Sludge Tank Mixer Software



Digester & Sludge Tank Mixer Software



	AO	AP	AQ	AR	AS	AT	AU	AV
1								
2		Jet Mixer		Impeller Mixer	Re>10000		Rotational Velocity	
3		Jet A	1	Lightnin A310	0.3	1	rps	
4		Jet B	2	Chemineer HE3	0.3	1	rpm	0.0
5		Jet C	3	45 deg PBT (4 blades)	1.27	2	deg/s	2.78
6		Jet D	4	45 deg PBT (6 blades)	1.64	2	rad/s	0
7				User defined	0.4	3		
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18								

Thank you

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