Introduction of

PLANT PLUS

Plant Diagnosis and Lifetime Improvement Service

Enhancing **planetary health**

JGC Corporation

EN Technology Center

April, 2022

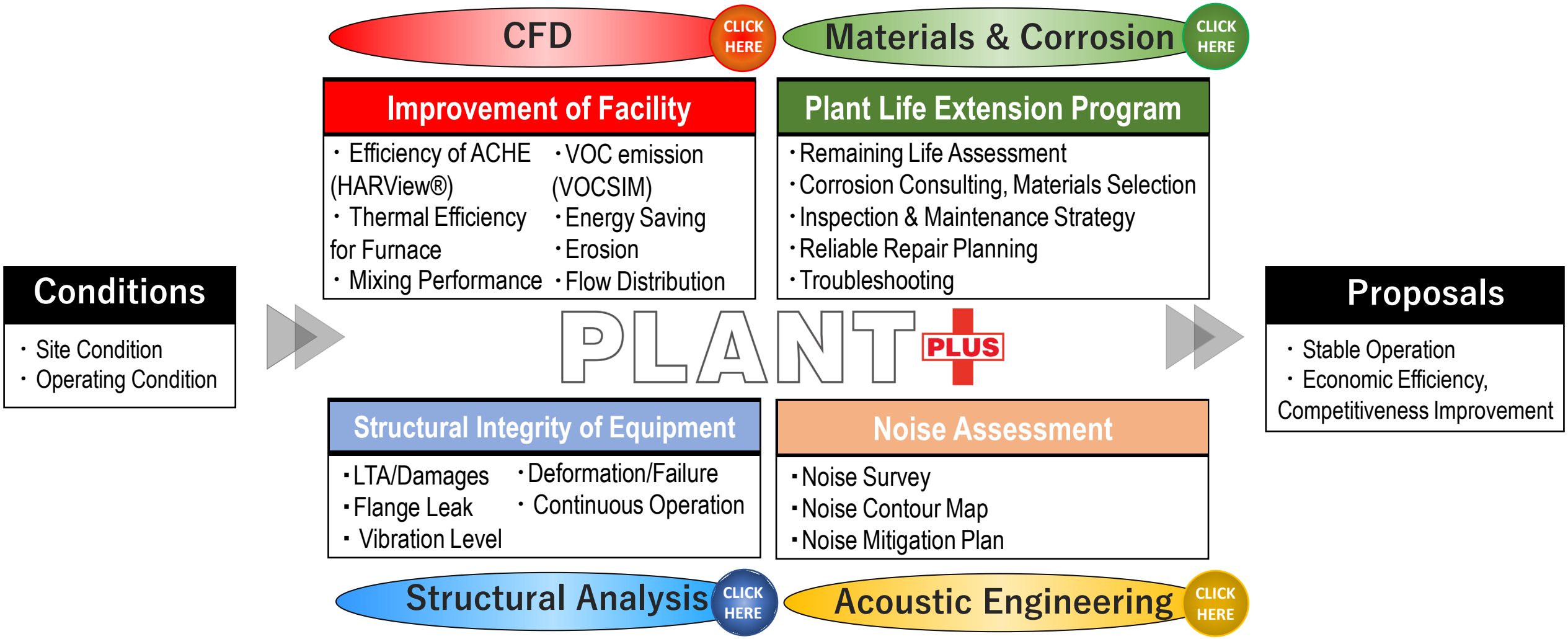
Outline of PLANT PLUS

- **PLANT PLUS is JGC's Comprehensive Engineering Service which has been developed to support the needs and to resolve the concerns of the existing plant owners across the world, and based on more than 1,000 plant diagnosis and improvement experiences for 50 years**

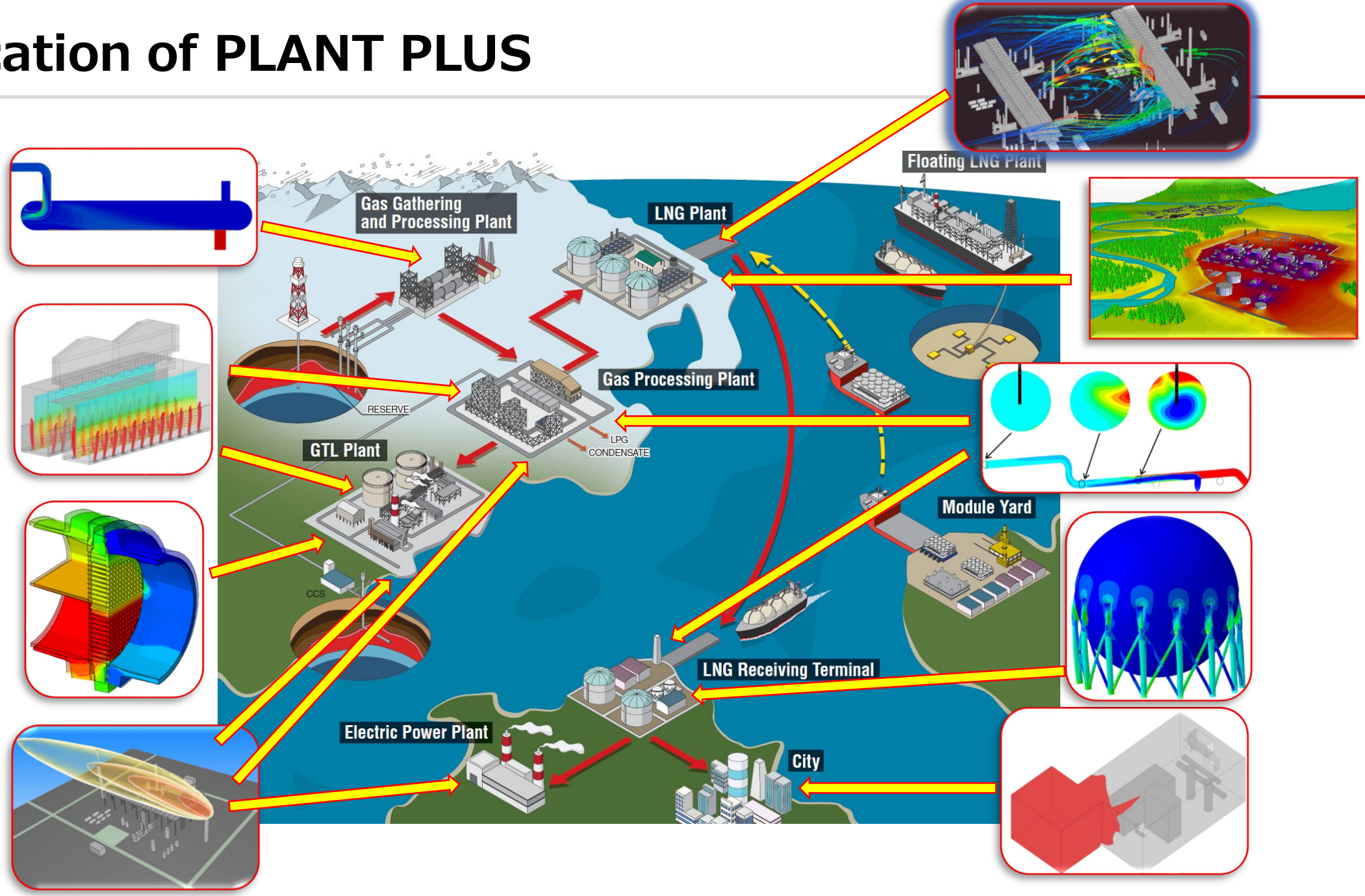
- **PLANT PLUS is comprised of four core technologies:**
  - Computational Fluid Dynamics (CFD)
  - Structural Analysis
  - Materials & Corrosion
  - Acoustic Engineering

- **PLANT PLUS can offer a variety of effective solutions for existing plant owners.**
  - Improve operational efficiency
  - Reduce and eliminate operational risks
  - Predict defects across the plants
  - Propose plant modification plan in accordance with the most up-to-date technologies and standards

Core Technologies and Work Flow

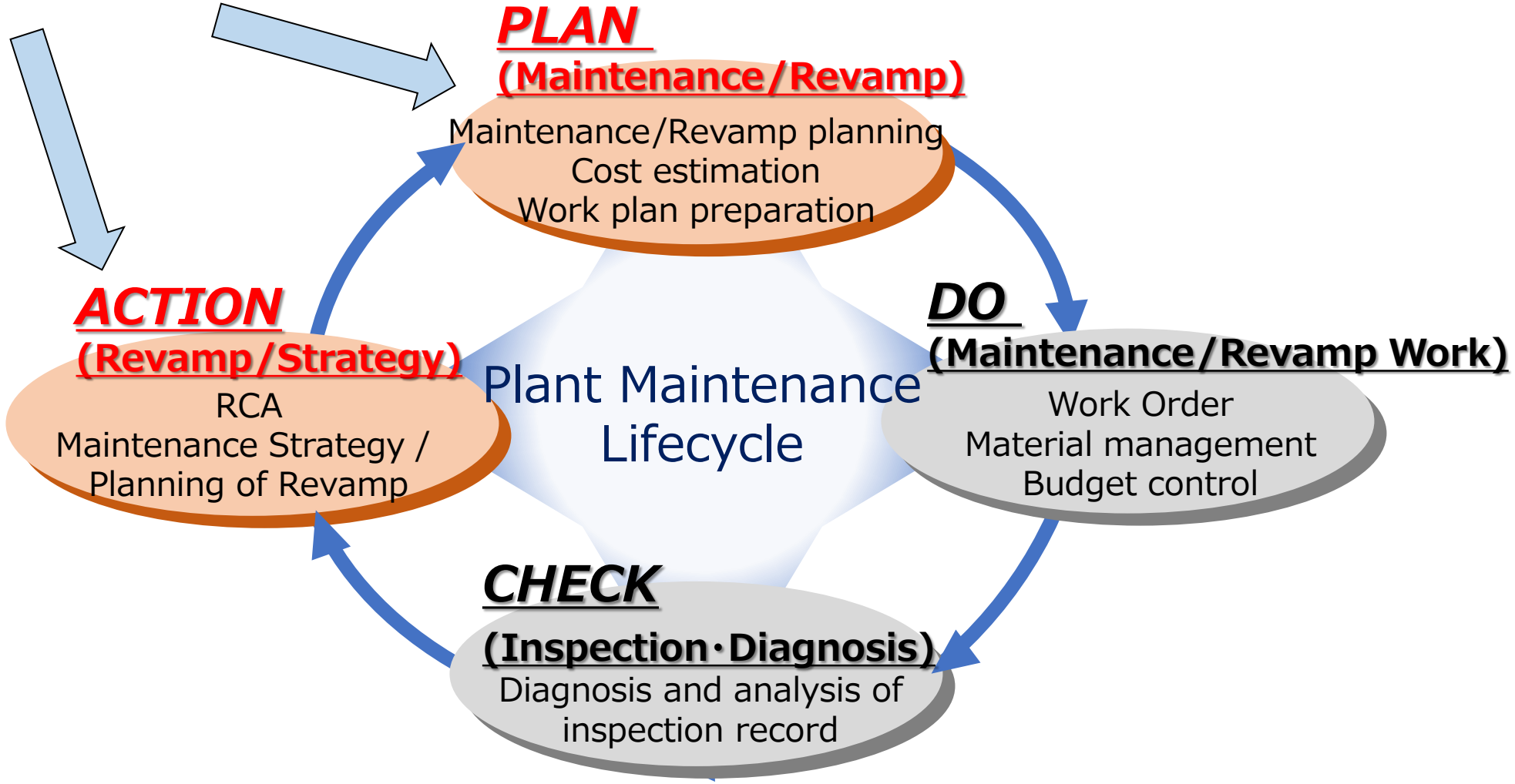


Application of PLANT PLUS



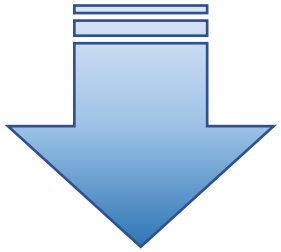
Role in Plant Maintenance Lifecycle

PLANT PLUS **supports strategy development and planning for maintenance and revamp**



Frequently Asked Questions and Concerns

- Can our plant improve energy efficiency?
- Which improvement plan is the most efficient?
- How can we prevent failures?
- Should we replace our corroded/damaged equipment?
- How can we prevent and/or reduce vibration?



PLANT PLUS can provide solutions!

Examples of Improvement of Facility
- Computational Fluid Dynamics (CFD) -

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Fired Heater Improvement

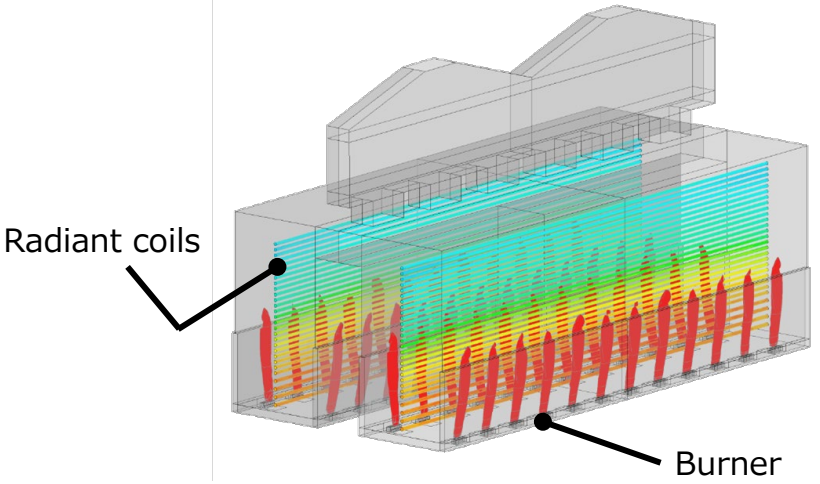
Do you have any of these issues?

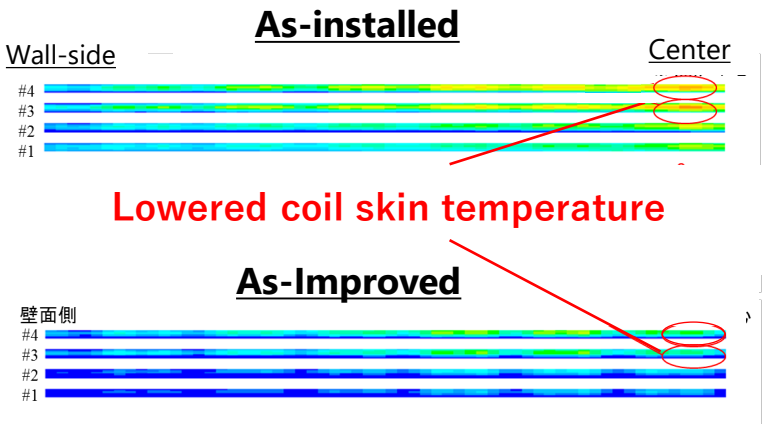
- ☹ **Poor performance and unreliable operation**
- ☹ **Reducing maintenance interval due to severe material degradation**
- ☹ **Need for engineering consulting partner for heater modification**

Fired Heater Improvement Solution

- Utilized **Computational Fluid Dynamics (CFD)** to simulate Combustion and Heat Transfer
- Assessed as-installed Heater Performance based on operation data and CFD Results
- Identified O&M Issues and their Root Causes
- Proposed and Evaluated Performance and Reliability Improvement Plan
  - Burner Layout Optimization for Replacement
  - Windbox Modification for Uniform Air Flow Distribution to each burner
- Provided the Technical Guidance for the Implementation of the proposed solutions

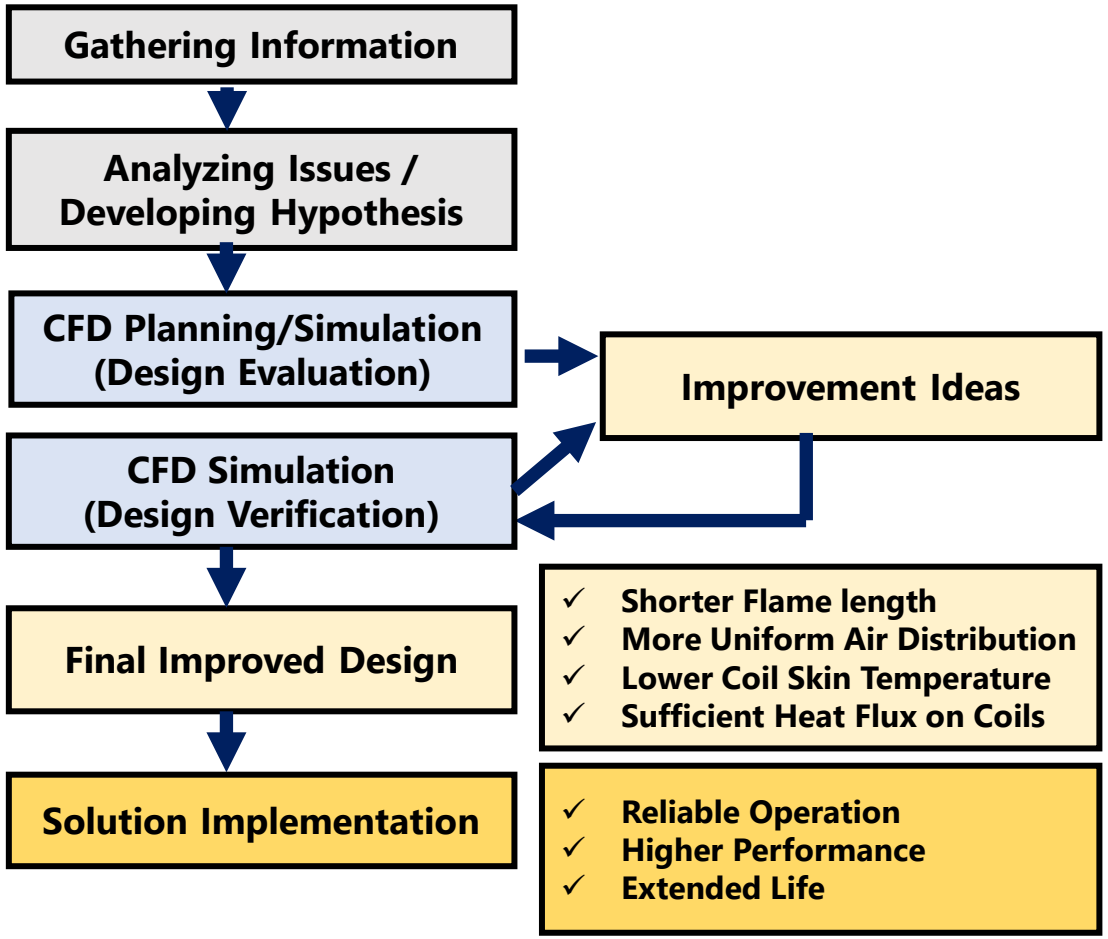
Examples of combustion and heat transfer analysis of Furnace (CFD)





Fired Heater Improvement

Workflow & Result



Our Strengths

- Years of experience in serving domestic customers for performance improvement of fired heaters utilizing the advanced CFD simulation
- Extensive experience in Combustion and Heat Transfer modeling and evaluating heater designs
- Collaboration with Material Engineering experts
- Customer-Focused Global Engineering Service Provider

Our Experiences

50+

Plants

Fired heater design evaluation and improvement studies with the advance CFD simulations

15+

Years

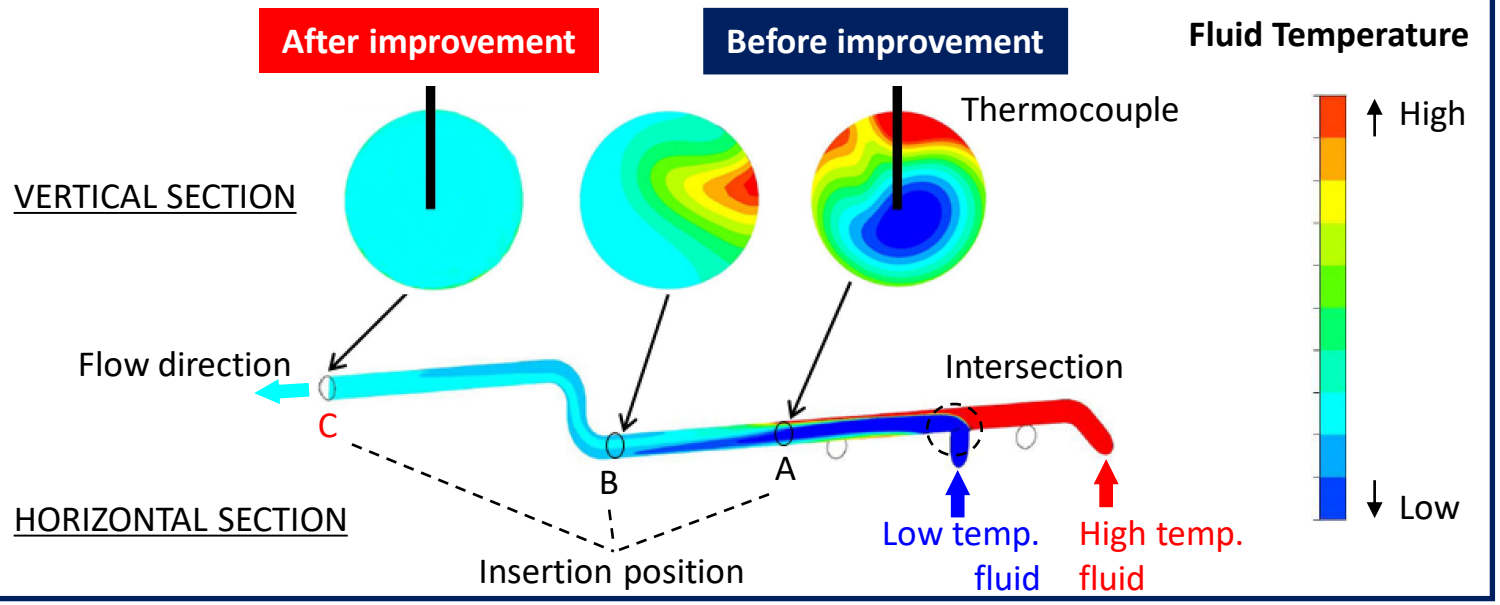
Simulation-based engineering service for plant diagnosis and lifetime improvement

OPTIMIZATION FOR INSTRUMENT POSITION

- A feedback loop in plant control may suffer from controllability issues caused by instrument installed at an improper location where the flow field is not well established or uneven
- **PLANT PLUS** offers recommendations on optimal instrument positions for better controllability of your asset based on our flow simulation

EXAMPLE

At thermocouple insertion position (A), fluid temperature was non-uniform. On the other hand, at thermocouple insertion position (C), the fluid temperature become uniform. Thus, suitable thermocouple insertion position (C) was proposed.

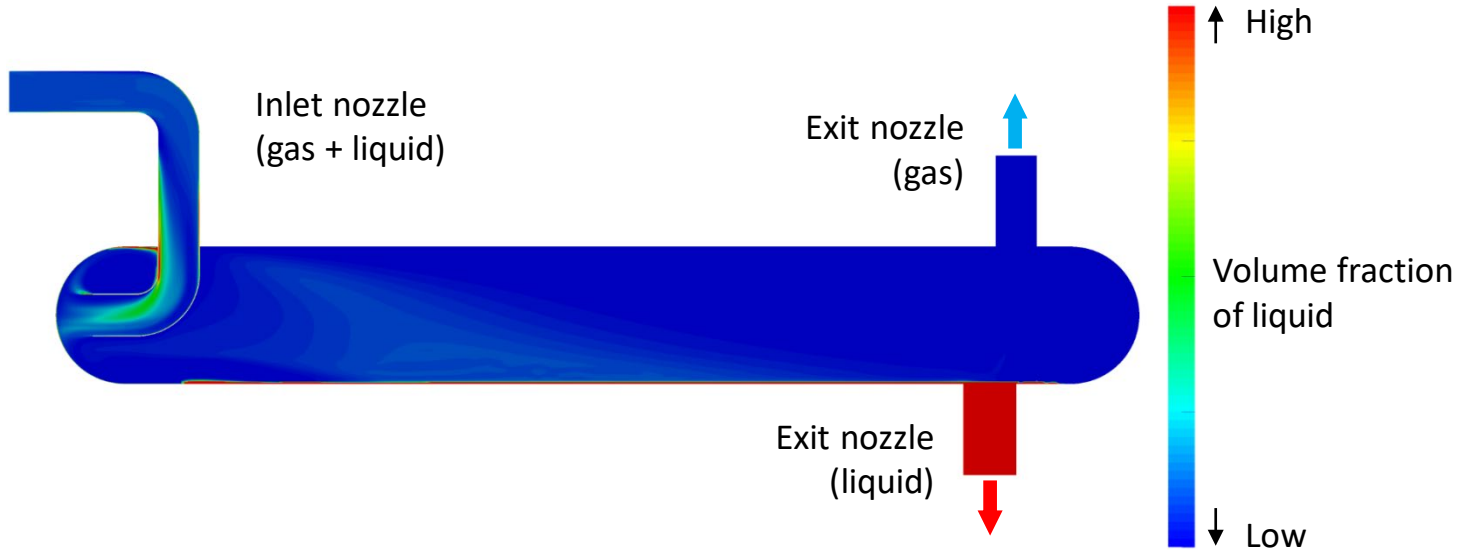


SEPARATION EFFICIENCY FOR GAS-LIQUID SEPARATOR

- Our modeling approach enables us to simulate a complex flow with liquid and gas inside a separator
- **PLANT PLUS** offers engineering solutions to improve under-performing gas-liquid separators by our detailed simulation technology

EXAMPLE

By appropriate direction of the inlet nozzle, inlet gas including mist was separated into gas (blue) and liquid (red) at each exit nozzles with sufficient separation efficiency.

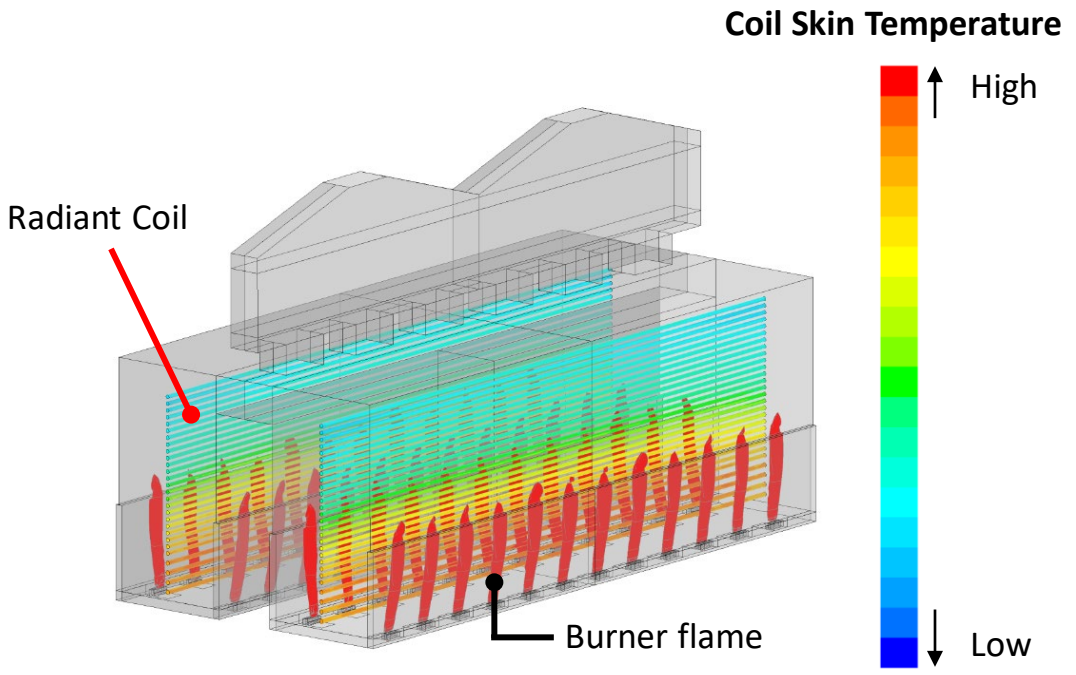


OPERABILITY IMPROVEMENT OF FIRED HEATER

- Operability of fired heaters is a primary concern. The common issues of aged heaters are hot spots, coking, flame impingement to the heating coils, and flame stability
- **PLANT PLUS** can identify the potential cause of the above issues and develop solutions to improve the operability of your heating equipment with years of experience

EXAMPLE

Estimation for distribution of heat flux and tube surface temperature, leading to best proposal for optimization of the thermo couple position, burner selection and so on.



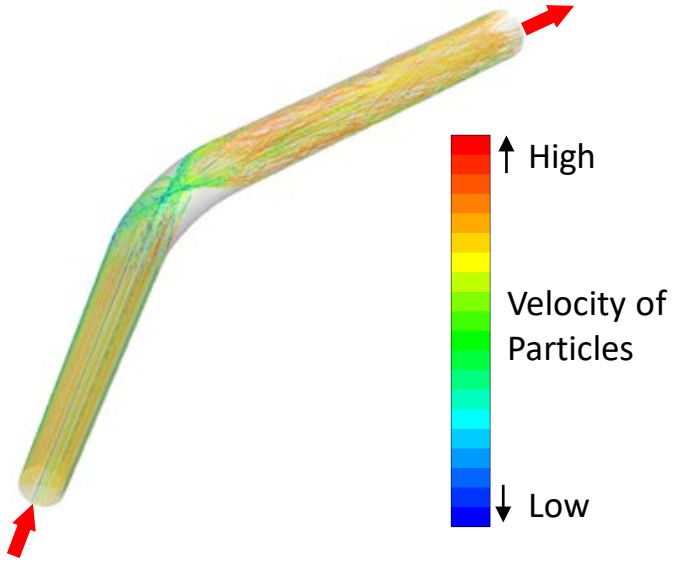
DIAGNOSIS FOR ERODED PIPE

- Failure of a pipeline component with breakage and fluid leaks often results in expensive repairs, considerable down time, and hazards to the plant workers. Erosion is one of the wear mechanisms that can cause such a failure; especially around elbow, valve, and reducer carrying multi-phase flow containing solid particles or liquid droplets.

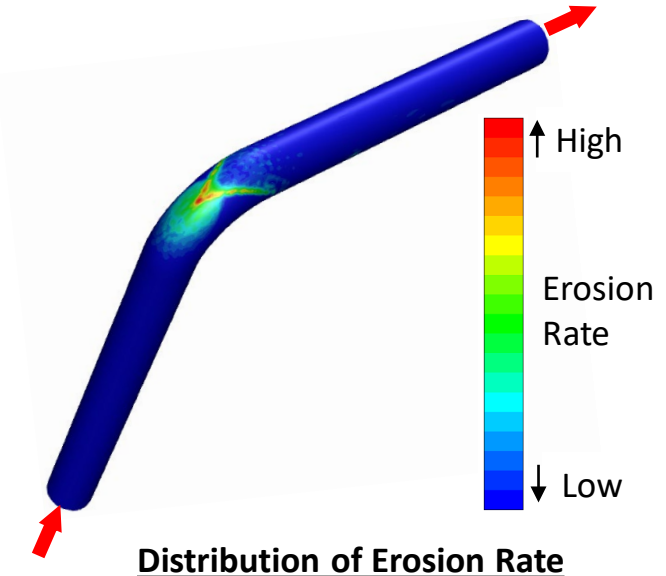
- **PLANT PLUS** can assess the remaining life of the pipeline component experiencing wall thinning due to erosion and develop solutions to extend its remaining life.

EXAMPLE

Distribution of erosion rate induced by particles or droplets can be predicted by CFD simulation with high accuracy. As a result, the remaining life of the component can be estimated.



Particle Trajectories



Distribution of Erosion Rate

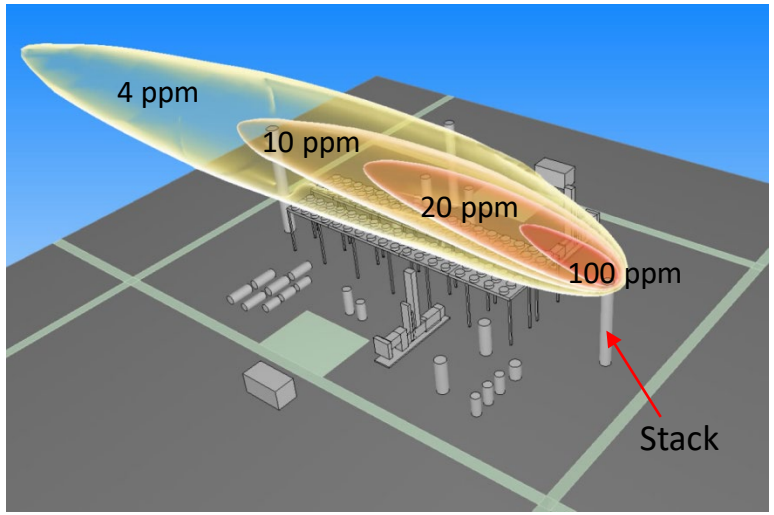
POLUTION PREVENTION

- The toxic or high temperature gas released from the stack may become a hazard to the plant workers and possibly neighbors of the plant if they are not properly studied or there are any changes in the plant operation

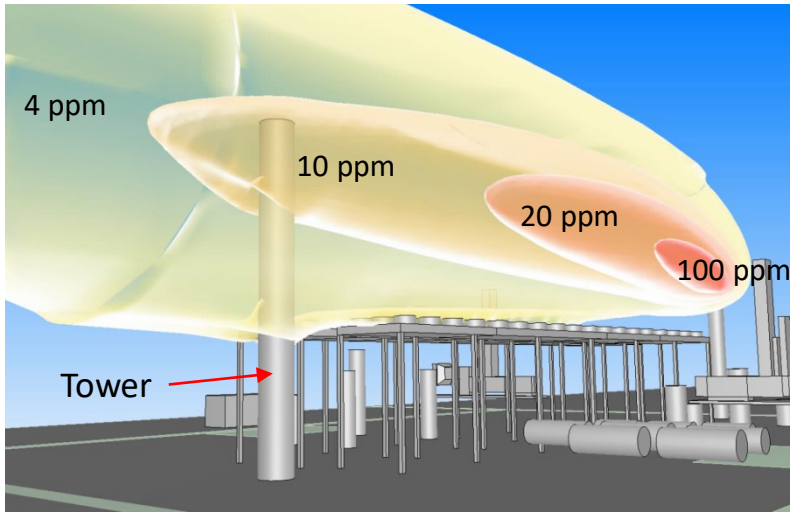
- PLANT PLUS estimates the affected area even with complex plant layout and assess its impact to the health and environment

EXAMPLE

Based on the simulation results of flue gas dispersion, solutions capable of preventing hot and toxic gas from harming human health and affecting plant operation can be proposed.



Distribution of SO_2 concentration predicted by CFD



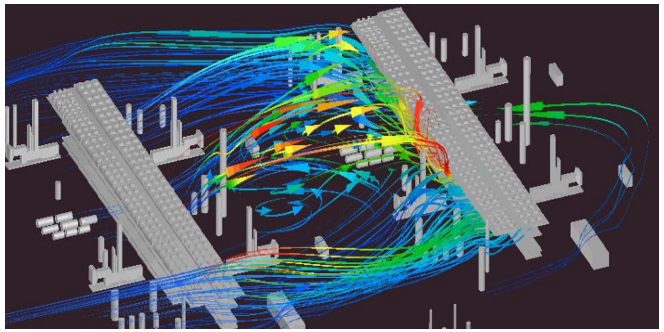
Distribution of SO_2 concentration around the tower

PERFORMANCE IMPROVEMENT FOR ACHE

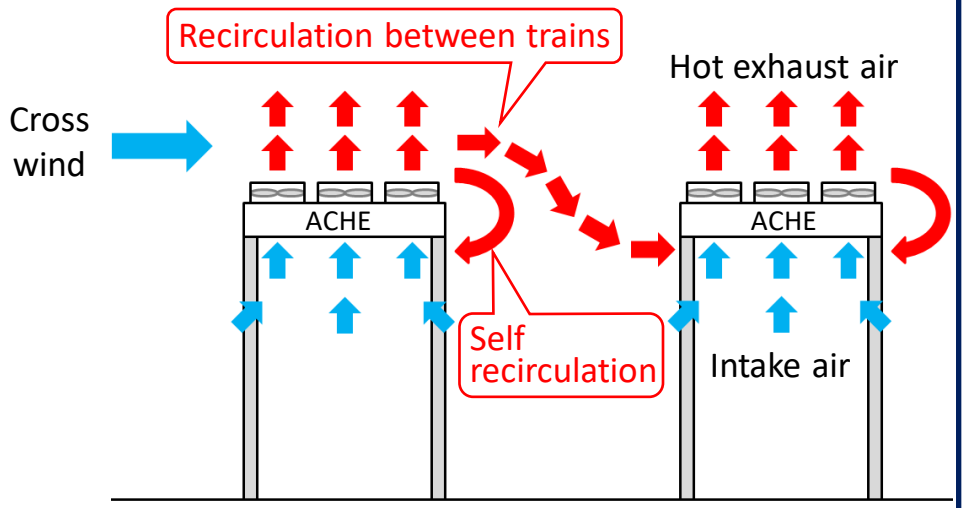
- Hot Air Recirculation (HAR) highly dependent on local wind conditions and plant layout significantly reduces the Air-Cooled Heat Exchanger (ACHE) performance
- **PLANT PLUS** offers a systematic HAR analysis package (HARview®) to optimize the ACHE performance for the specific local condition

EXAMPLE

- HAR CFD analysis is firstly performed to reproduce the current conditions.
- The effect of various mitigations can be evaluated by CFD analysis.
- The most effective and practical mitigation plan will be proposed.



HAR CFD Analysis



Hot Air Recirculation (HAR) Phenomenon

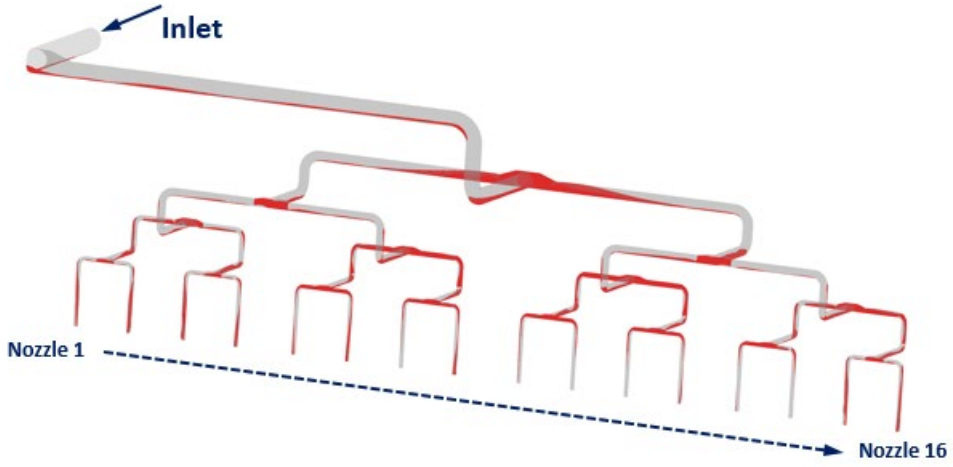
ASSESSMENT OF FLOW DISTRIBUTION

- One of the key elements in the piping design is to properly distribute the process fluid flow as intended to ensure that downstream equipment can function at its best performance. This becomes more challenging with the multi-phase process fluid.

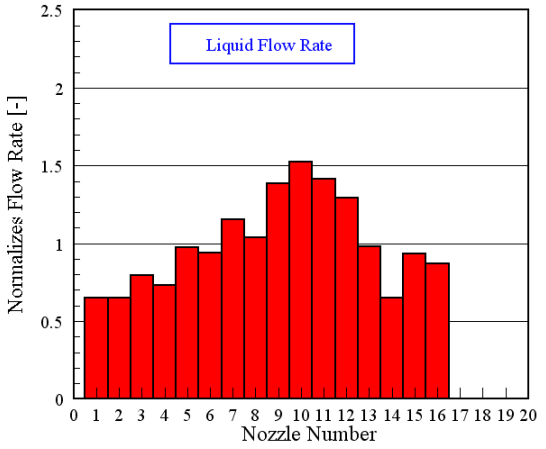
- **PLANT PLUS** can evaluate flow distribution within a pipeline system with multiple paths and develop solutions, which can be applied for pipeline system found in various process plants. (for example, tournament header of air-cooled heat exchangers (ACHE) in refinery plant and inlet piping of slug catcher in gas treatment plant).

EXAMPLE

It is important to ensure that vapor is distributed into each nozzle as evenly as possible for manifold inlet piping of ACHE. Based on the simulated flow distribution, the header design can be improved for more even distribution by taking counter-measures if necessary.



Flow Distribution for Liquid (Red)



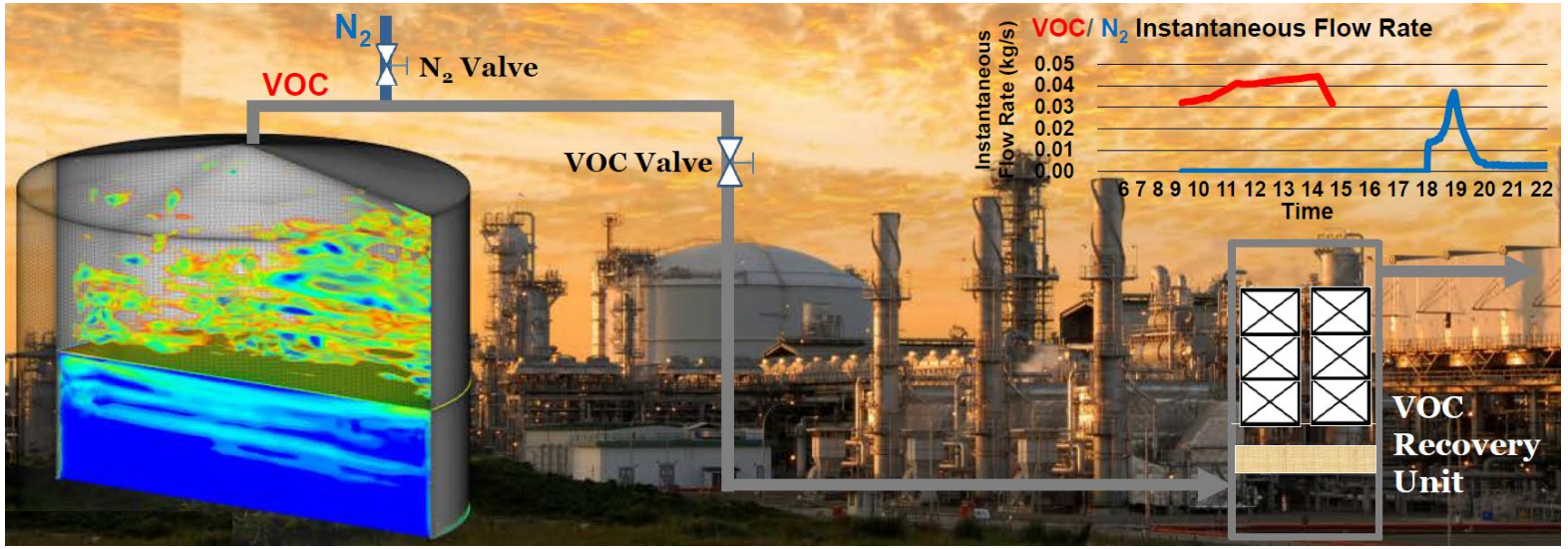
Distribution of Liquid Flow Rate

SUSTAINABLE/COST-EFFECTIVE VOC EMISSION MANAGEMENT

- Today's plant owners are required to comply with more stringent environmental regulations while remaining profitable.
- **PLANT PLUS** offers an optimized engineering solution to manage VOC (Volatile Organic Compounds) emission from storage tanks by minimizing VOC recovery unit size as well as N2 usage with our advanced simulation technology.

EXAMPLE

State-of-the-art VOC emission modeling can predict the amount of VOC emitted from the storage tank which needs to be removed by the recovery unit. This technology allows us to properly size the VOC recovery unit so that the plant owners can save both CAPEX and OPEX



Examples of Structural Integrity of Equipment

- Structural Analysis -

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Plant Diagnosis and Lifetime Improvement Service

Do you have any of these issues?

☹ **Mechanical damage occurred!**
Can we continue operation? Should we replace?

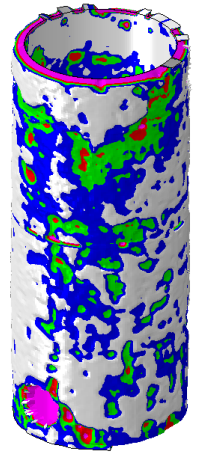
☹ **What is the root cause?**

☹ **Which improvement plan is the most efficient?**

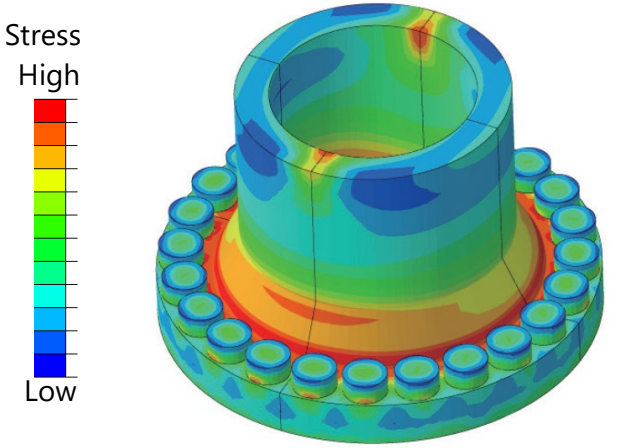
PLANT PLUS[SM] Solution

- JGC's simulation-based engineering service
- Investigate the root cause of the mechanical damage
- Diagnose whether a damaged equipment can continue operation or should be reinforced, revamped partially, replaced totally
  - ➢ Leads to reduced cost of repair/revamp
- Propose effective improvement/reinforcement plan

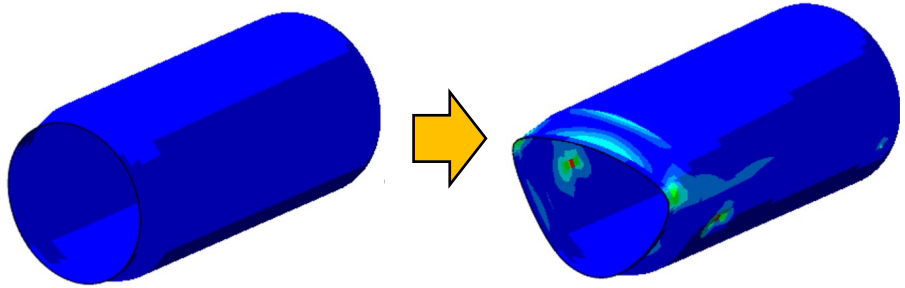
Examples of Finite Element Analysis (FEA)



(1) External Corrosion Analysis Model by Laser Scanning



(2) Stress Distribution in Flange Caused by Bolt Tightening



(3) Creep Deformation of Vessel during PWHT

Plant Diagnosis and Lifetime Improvement Service

Workflow & Result

Step-1 Data and Information Collection

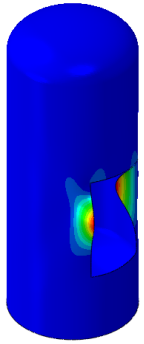
Step-2 Site Survey (if necessary)

Step-3 Scenario Planning:
Root Cause, Damage Mechanism
Improvement/Reinforcement Plan

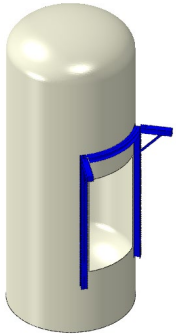
Step-4 Plan Mitigation against Risks

Step-5 Assessment Results
- High Possibility Root Cause
- Effective Solutions

Example: Large opening discovered during Turnaround



Assessed buckling risk for vessel with large hole



Proposed reinforcement plan

Our Strengths

- Diagnosed from various perspectives such as international design codes, fitness-for-service codes, post construction codes, guidelines often used in the plant industry, and JGC own company standards
- Provided quantitative and easy-to-understand study results and countermeasures using structural analysis techniques such as finite element analysis (FEA)

Our Experiences

1000

Plant Diagnoses

Structural analysis technology, computational fluid dynamics technology and noise assessment/control technology for 1,000+ diagnoses

50+

Years

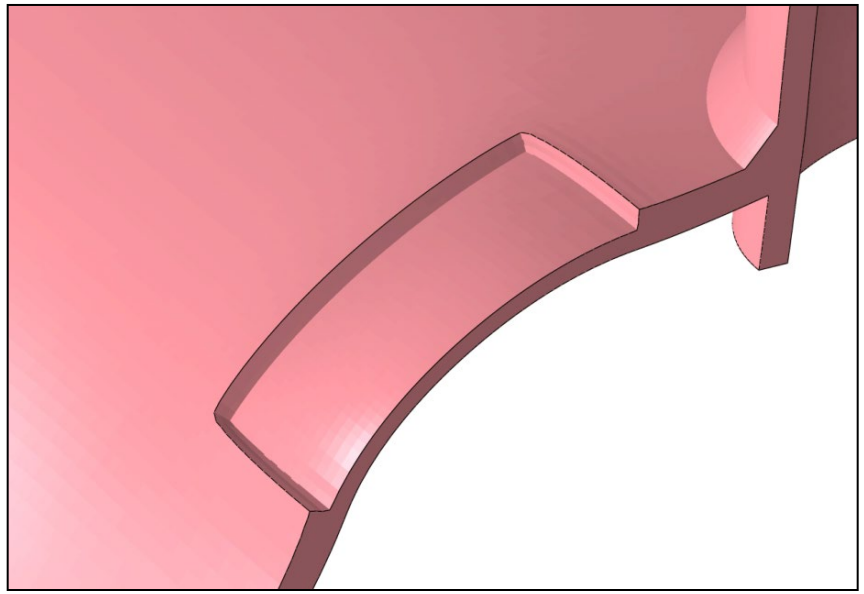
Simulation-based engineering service for plant diagnosis and lifetime improvement

ASSESSMENT FOR DAMAGED EQUIPMENT

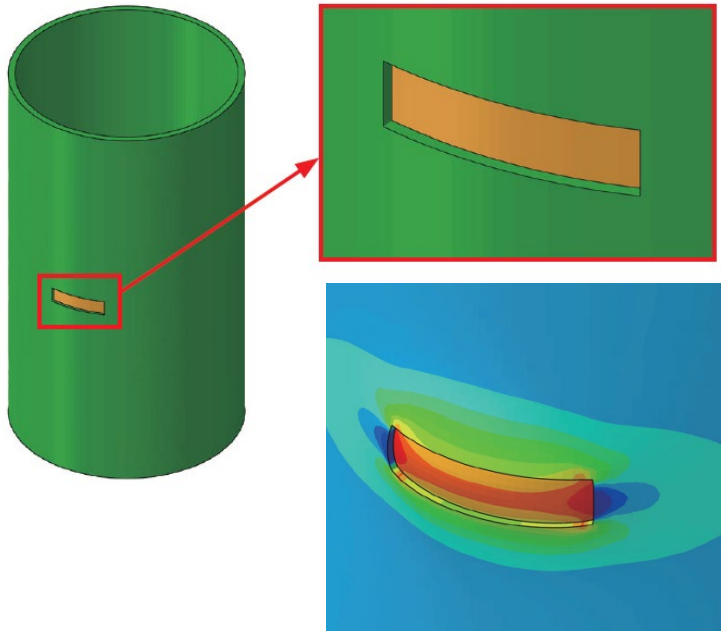
- **PLANT PLUS can evaluate whether a damaged equipment (metal loss, crack-like flaws, distortions, dents, etc.) can continue operation or not. This assessment can save the cost of replacement or reinforcement.**

- **JGC has much experience and knowledge of the following Fitness-For-Service codes: API 579-1/ASME FFS-1, BS 7910, WES 2820 (The Japan Welding Engineering Society*), etc.** *JGC is a committee member of this code.

EXAMPLE



①Analysis model of Local metal loss around equipment nozzle



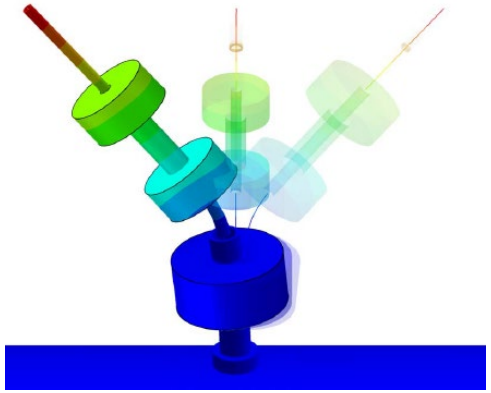
②Analysis model of corroded pipe and stress distribution

DIAGNOSIS OF VIBRATION

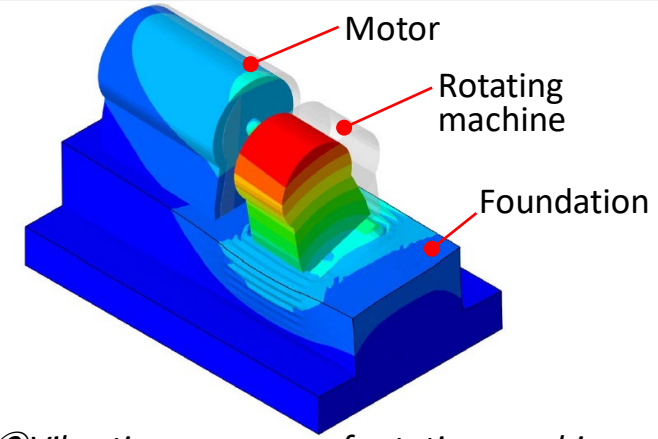
- **PLANT PLUS can provide the following services.**
  - ➢ Vibration measurement (speed, direction, dominant frequency)
  - ➢ Assessment of vibration level by referring the various criteria (ISO, API, JIS or JGC company standards, etc.)
  - ➢ Root cause study
  - ➢ Proposal of countermeasures

- **JGC has solved more than 300 vibration troubles for the following facilities.**
  - ➢ Rotating machines (pumps, compressors, agitators, air fin coolers etc.)
  - ➢ Towers, tanks, heat exchangers
  - ➢ Piping system, instruments, platforms, foundations

EXAMPLE



①Vibration response of pressure gauge



②Vibration response of rotating machine

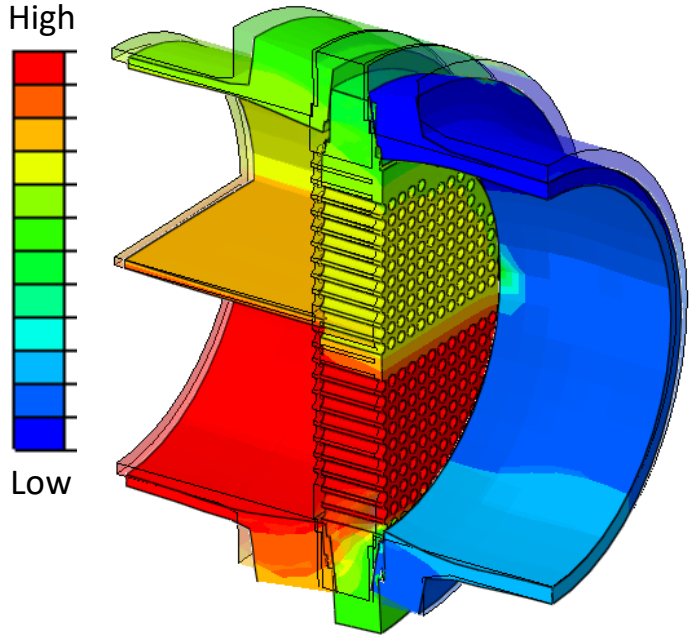
ROOT CAUSE & COUNTERMEASURES OF DEFORMATION/FAILURE

- **PLANT PLUS can investigate the root cause, propose the countermeasures, and evaluate whether you can operate continuously.**

EXAMPLE

① *Flange Leakage*

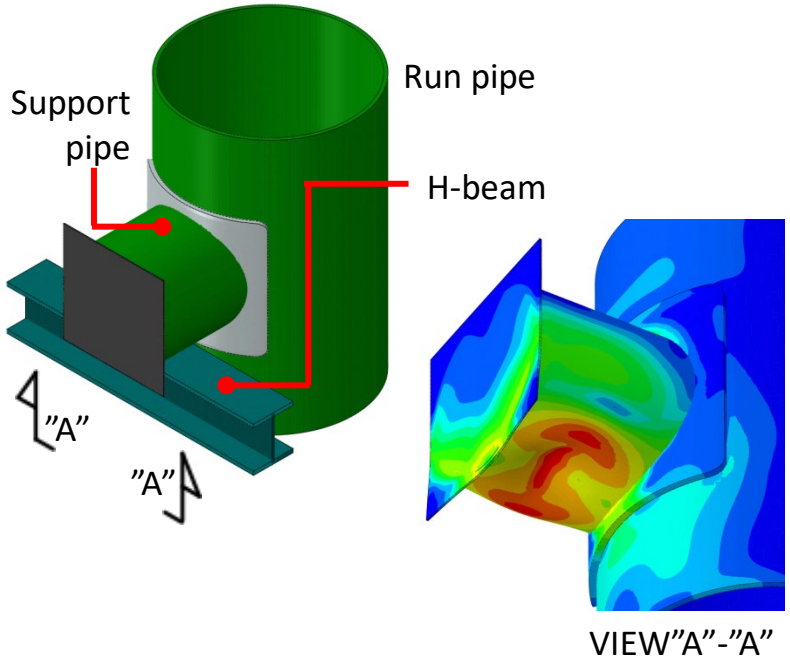
Analyze deformation amount, generated stress, bolt axial force, gasket surface pressure, thermal expansion/contraction and bolt fastening force



Temperature distribution and deformation of flange

② *Deformation of Piping Support*

The magnitude of the load which caused the deformation can be studied by FEA. PLANT PLUS can propose how reinforce against the load mentioned above.



Deformation of support by elastic-plastic analysis

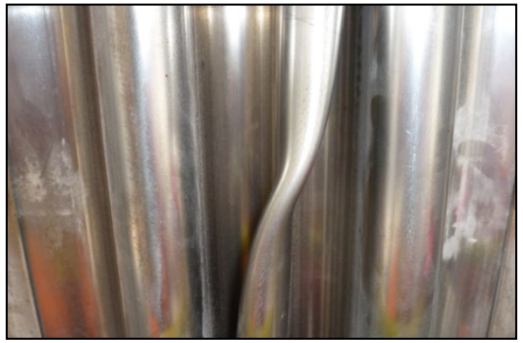
ROOT CAUSE & COUNTERMEASURES OF DEFORMATION/FAILURE

(continued)

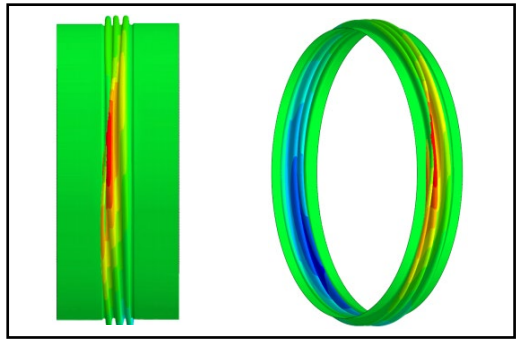
EXAMPLE

③ *Deformation of Expansion Joint*

Thermal expansion behavior and the load which cause the deformation can be studied by FEA.



Deformed expansion joint



Deformation studied by FEA

④ *Abnormal Temperature Rising, Fire Damage*

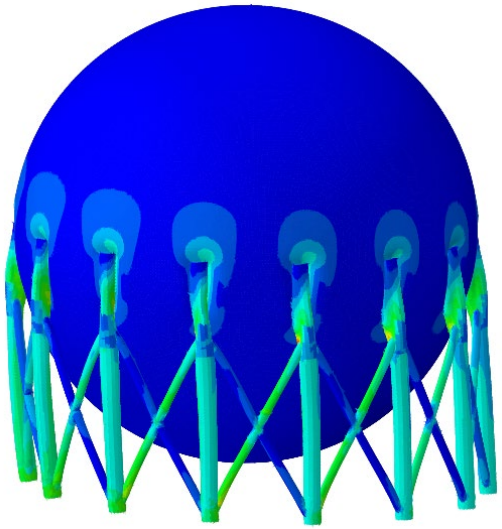
When the trouble such as abnormal temperature rising or fire occurs, PLANT PLUS can study the stress generated on structures and assess the remaining life.

Creep rapture of furnace tube

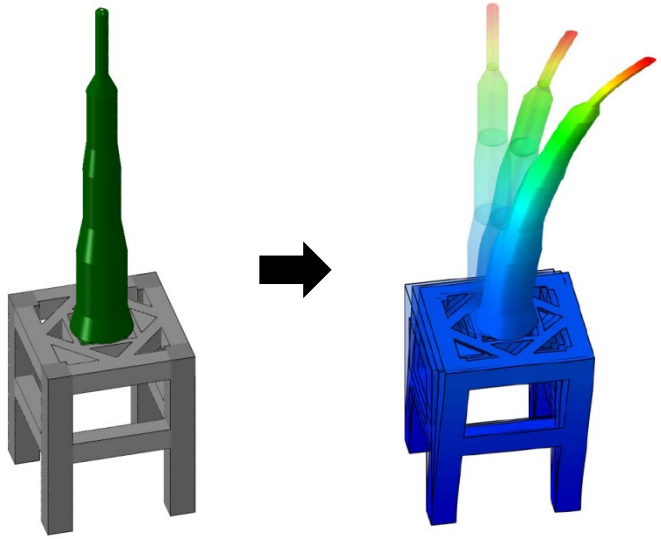
EVALUATION FOR SEISMIC DESIGN

- **JGC has much experience and knowledge of the seismic design.**
- **PLANT PLUS can evaluate the existing/aging facilities from the following view points.**
  - ✓ Do they satisfy the latest requirements in design code?
  - ✓ What kind of modification and/or reinforcement are necessary?
- **Object equipment: Tanks, Tower, Piping, Nuclear Equipment, etc.**

EXAMPLE



① *Strength analysis of columns and braces of spherical tank*



An integrated analysis model of tower and table top

Deformation by response analysis

② *Seismic response analysis*

Plant Life Extension Program (PLEP)

- Materials & Corrosion -

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Plant Life Extension Program (PLEP)

Do you have any issues about plant materials ?

☹ **Plant Aging**

Approaching the life, material degradation is accelerating…

☹ **Operating Condition Changing**

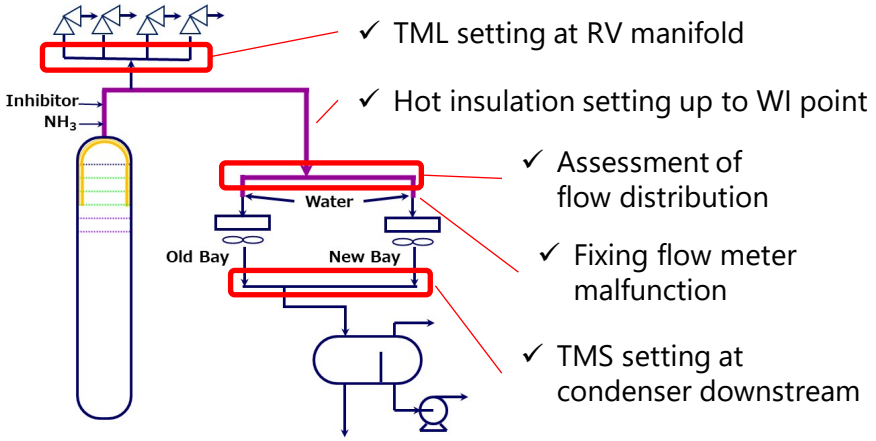
Conditions becoming more severe, deviating the design range…

☹ **Competitiveness Stagnating**

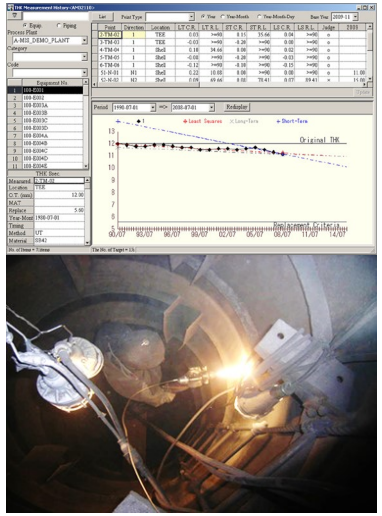
O&M cost increasing, maintenance intervals shortening…

PLEP Solutions

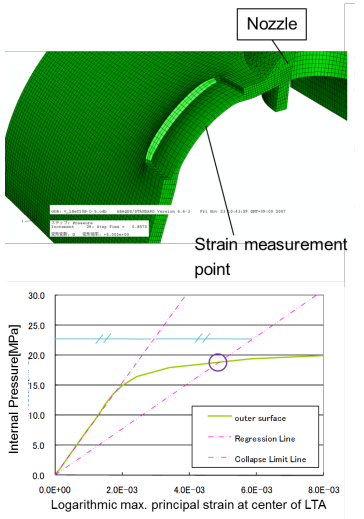
- Identification of facility and locations having materials and inspection concerns
- Suggestion of practical and economical solutions to solve the concerns
- Projection of revamp work, inspection and maintenance work, etc., to extend plant life



Example of Improvement for CDU Overhead System



Inspection Result and Thermal Spray Coating for Life Extension



Fitness For Service about Local Thinning Area

Plant Life Extension Program (PLEP)

Workflow & Result

1st Step: Plant Integrity Assessment (PIA)

Finding / Screening

- ✓ Assessment of materials selection, inspection program, etc.
- ✓ Site visit and discussion with client.

2nd Step: Integrity Improvement Initiative (III)

Detail Study

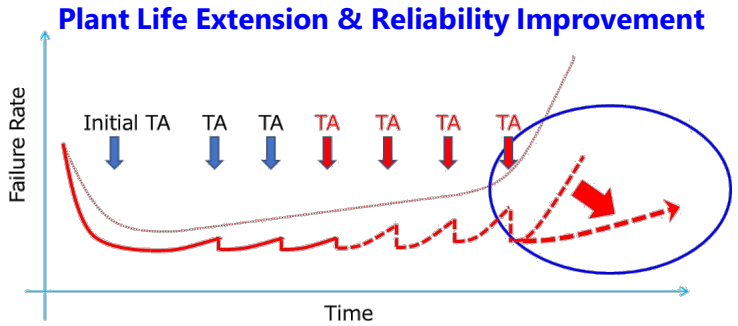
- ✓ Client and JGC joint team to conduct detailed plant diagnosis, and to develop improvement strategy and action plans.

3rd Step: Life Extension Project (LEP)

Project Development and Execution

- ✓ The team to complete the project in line with conclusions.

Result of PLEP



Our Strengths

- ✓ **One-stop** service of engineering, construction and maintenance services to make convenient for client
- ✓ **Practical and efficient** approaches including workshops and site observations will provide best solutions
- ✓ **Easy** methods without special software will avoid client burden
- ✓ **Flexible** program will run along with client's demands to the goal.

Our Experience

- ➢ **CDU/VDU**, Asia

  83 findings / 22 recommendations
- ➢ **Gas Processing Unit**, Middle East

  116 findings / 34 recommendations
- ➢ **GOSP**, Middle East

  88 findings / 7 key recommendations

Noise Assessment

- Acoustic Engineering -

Enhancing **planetary health**

Noise Assessment

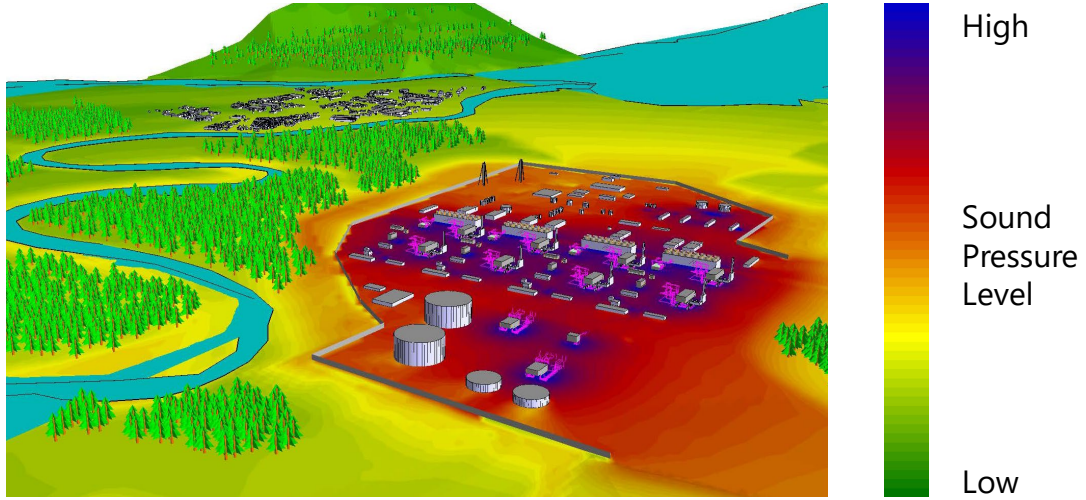
Do you have any of these issues?

- ☹ **Noisy work environment**
- ☹ **High costs noise mitigation for noise emitters**
- ☹ **Need for consulting partner for noise assessment**

Noise Assessment Solutions

- By noise survey;
  - ➢ identified noise sources
  - ➢ produced noise contour maps before and after noise mitigation plans
- Propose most effective and cost-minimum noise mitigation plans based on result of noise simulation
- Verify the effectiveness of noise mitigation plans

Noise contour map



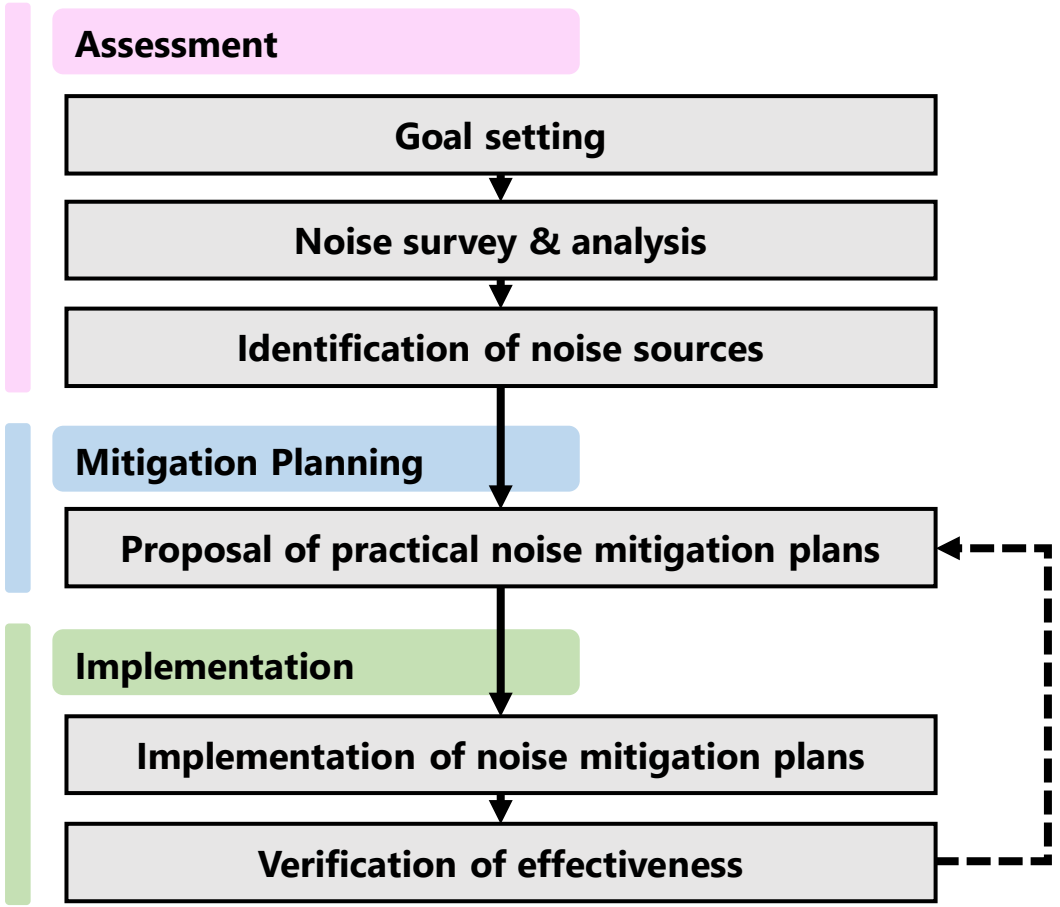
Example of noise mitigation plan (acoustic insulation)

Before

After

Noise Assessment

Workflow & Result



Our Strengths

- Experienced for noise assessment/control technologies to domestic and overseas clients for many years, and solved various noise problems
- Provided services for noise survey, evaluation, planning of countermeasures, and confirmation of effectiveness after implementation of countermeasures

Our Experiences

600+

Cases

Noise assessment/control technology for 600+ cases.

50+

Years

We have been accumulating noise assessment/control technologies for more than 50 years through EPC businesses and consulting services.

If you want to know more, please feel free to contact us.

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