

Natural Gas Systems

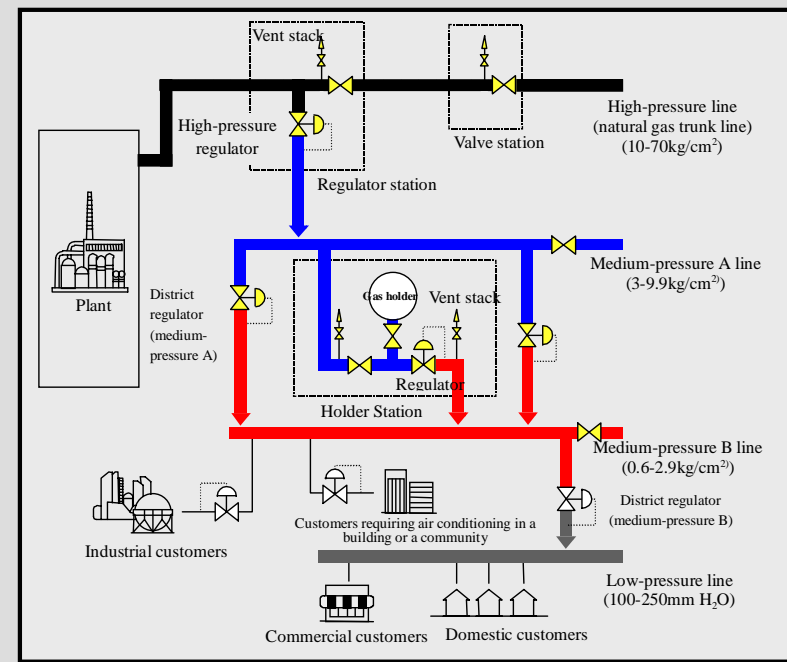
Pipe breaks in the 1994 Northridge EQ



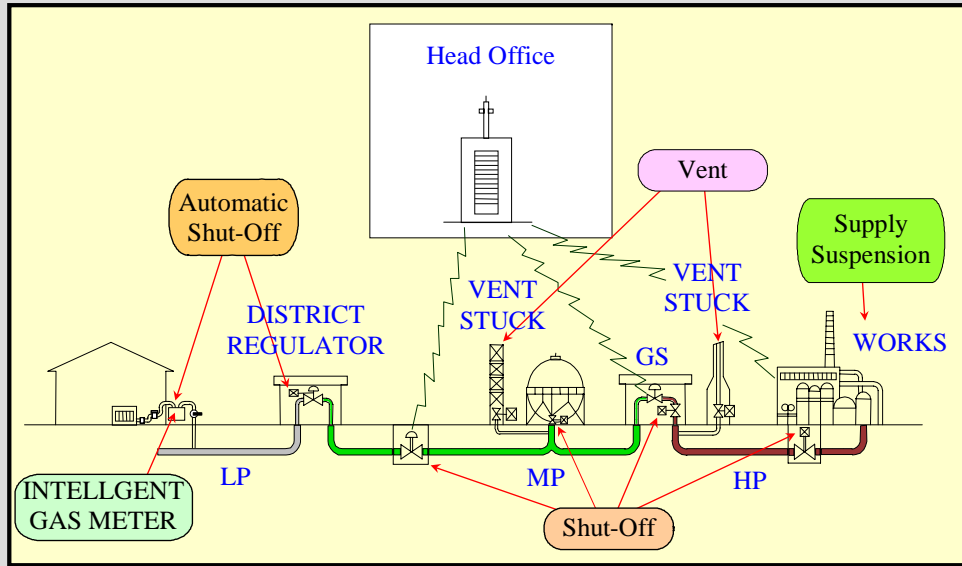
Performance of Gas Pipes in the 1993 Hokkaido Nansei-Oki EQ



City Gas Supply Systems in Japan



Outline of Emergency Control



Automated Supply Shutoff in Case of Emergency



Intelligent
Gas Meter



Shut-off valve



District
Regulator

Service Area of Osaka Gas Co.



Damage to Natural Gas System in the Kobe EQ

- Production facility: no damage
- Gas holders, governors: no damage
- High-pressure transmission line: no damage
- Medium-pressure transmission line: **106 leaks**
- Low-pressure distribution lines: **26,459 leaks**
 - mostly old steel pipes with screw joints
 - no damage to polyethylene pipes

Damage Distribution of Medium Pressure Gas Pipes in Kobe Area



Performance of Gas Pipes in the Kobe EQ

Daikai Station

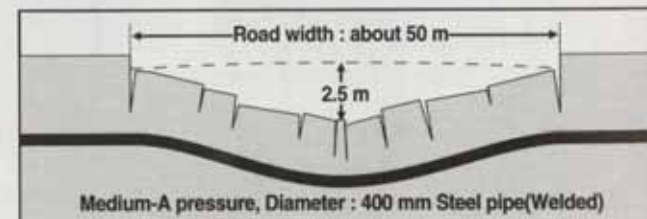


Fig.4 Schematic of cave-in near Daikai station

Performance of Gas Pipes in the Kobe EQ

Port Island



Gas Pipe Damage



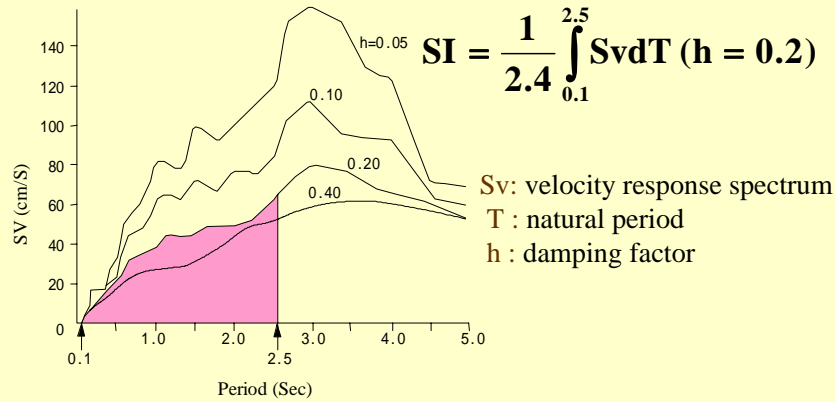
Water from Gas Pipe



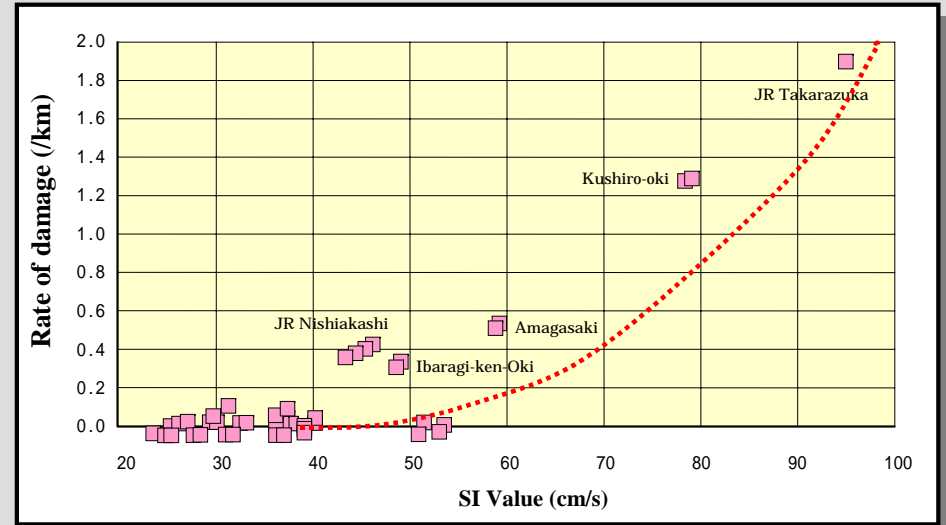
Break of Screw Joint Pipe

Spectrum Intensity : SI

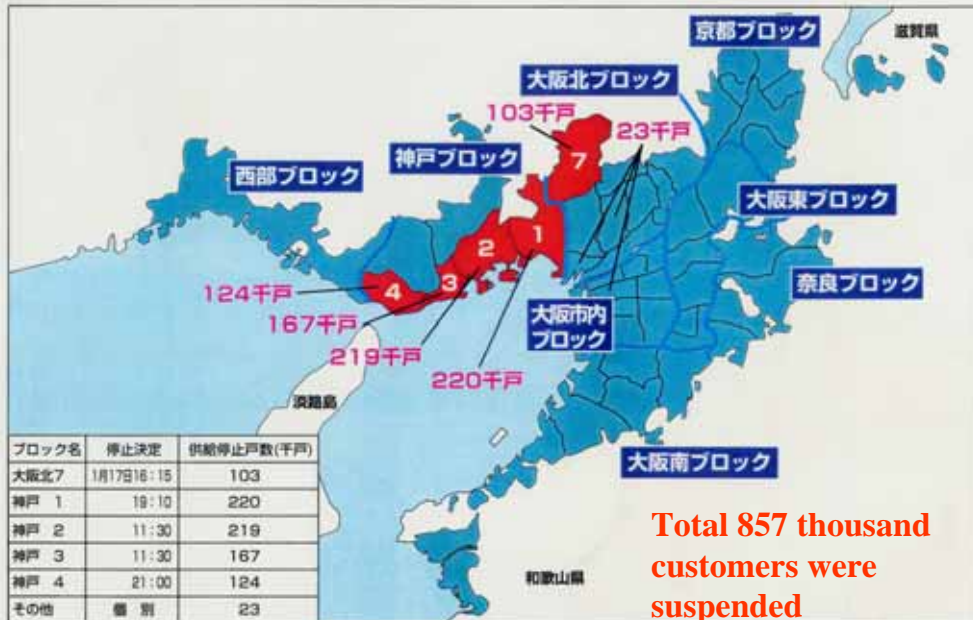
Velocity response spectrum
(h = damping factor)



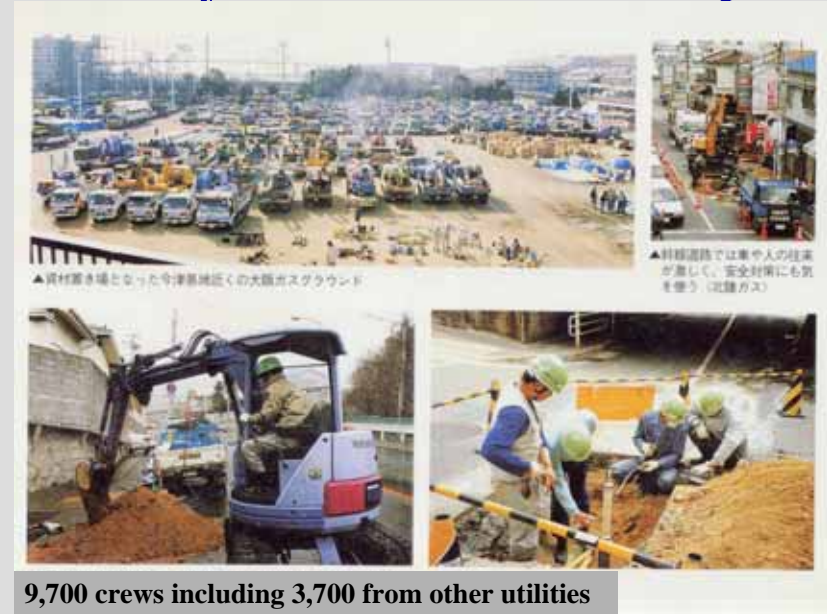
Relation Between SI Values and Damage Ratio of Screwed Joint Pipes



Supply Shut-off of Osaka Gas after the Kobe EQ



Restoration of Natural Gas Supply System after the Kobe EQ



Procedure of Gas Supply Restoration

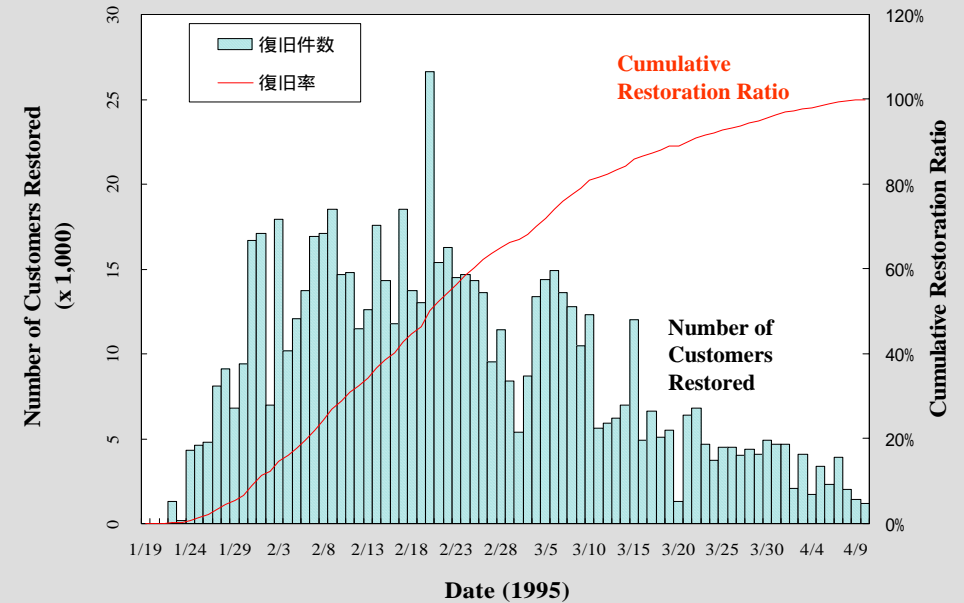
Medium-pressure lines

prioritization considering public importance
e.g. hospitals, garbage plants, crematories

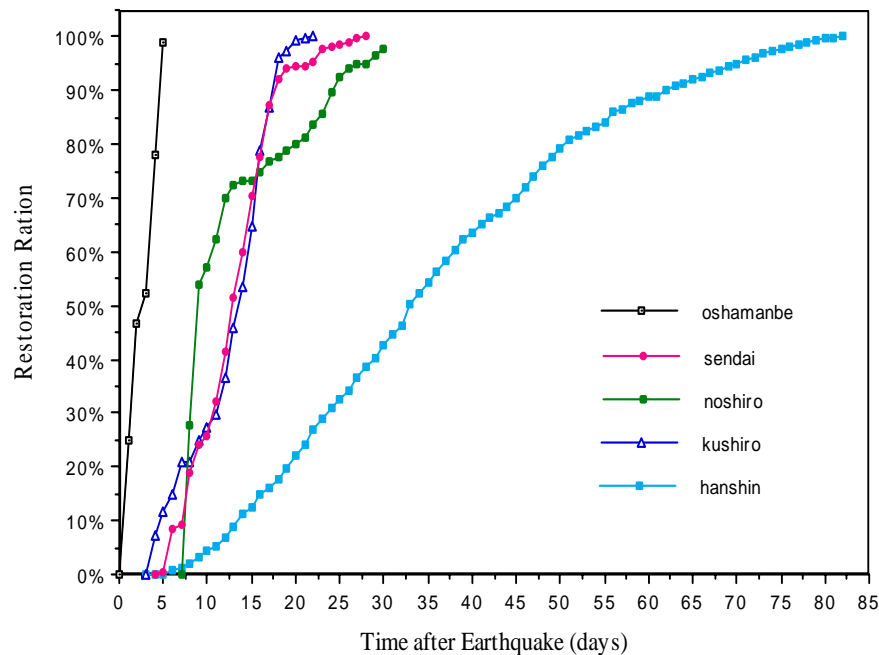
Low-pressure lines

1. Close valves of customers
2. Isolation of restoration sectors (3,000 - 4,000 customers)
3. Inspection and repair pipes buried under roads
4. Inspection and repair pipes and equipment in houses
5. Restore gas supply

Restoration of Osaka Gas after the Kobe EQ



Restoration of Gas Supply after Earthquakes



Seismic Countermeasures of City Gas Systems

Hardware

- Earthquake resistant pipes and joints
- Gas meter with seismic sensor

Emergency Operation

- Early damage estimation based on seismic monitoring
- Appropriate size of blocks and seismic intensity level for service suspension

Restoration Strategies

- Integrated restoration information (e.g., roads, water)
- Prioritization