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The formulae $\frac{\partial \rho U_i}{\partial t}+\frac{\partial}{\partial x_j}(\rho U_i U_j)=-\frac{\partial P}{\partial x_i}+\frac{\partial}{\partial x_j}\left(\mu\frac{\partial U_i}{\partial x_j}\right)+g_i(\rho-\rho_0)$ *for building* $\frac{\partial}{\partial x_j}(\rho\overline{U_i}\overline{U_j})=-\frac{\partial \overline{P}}{\partial x_i}+\frac{\partial}{\partial x_j}\left(\mu\frac{\partial \overline{U_i}}{\partial x_j}-\rho\overline{u_i'u_j'}\right)+g_i(\rho-\rho_0)$ *state of the art* $\frac{\partial}{\partial x_i}(\rho\overline{U_i}\overline{H})=\frac{\partial}{\partial x_i}\left(\lambda\frac{\partial \overline{T}}{\partial x_i}-\rho\overline{u_i'h'}\right)$ *biomedical research facilities.*

Fall Protection

Per OSHA data, falls are the leading cause of death in construction and operation and maintenance (O&M) activities – in 2023 alone, the U.S. Bureau of Labor Statistics (BLS) reported 423 out of 1,075 construction fatalities were due to falls, despite being preventable.[1] During construction, work often involves activities including unprotected edges and openings, elevated platforms, or scaffoldings. During O&M activities, maintenance technicians often require ladders or lifts to gain access to ceiling panels, ductwork, and equipment above the ceiling. Given the risks of fall are present for both construction and O&M, OSHA requires fall protection when work is performed at elevations of six feet during construction (see 29 C.F.R. 1926.501)[2] and at four feet in general industry settings (see 29 C.F.R. 1910.28),[3] which include most O&M activities.

Fall Protection Systems

There are three types of fall protection systems used to minimize the risk of falls during construction and O&M:

- **Fall Prevention**: Typically, this is the safest approach, as this system removes fall hazards by using physical controls such as guardrails to prevent workers from falling to lower levels (see 29 C.F.R. 1926.502(b)).[4]
- **Fall Restraint (Travel Restraint)**: When implementing fall prevention is not feasible, this system prevents workers from accessing areas with fall hazards. A fall restraint system consists of a body belt or harness connected to a fixed-length lanyard and anchorage point. When used properly, a fall restraint will not allow workers to fall from any distance even when fully extended.
- **Fall Arrest**: Designed to safely stop (or arrest) a fall that has already happened. Examples of fall arrest systems include safety nets (see 29 C.F.R. 1926.502 (c)) and personal fall arrest systems (PFASs) (see 29 C.F.R. 1926.502(d)).[4] A PFAS consists of a full body harness, an anchorage point, lanyard, and lifeline that prevents workers from hitting the surface below. Fall arrest systems should be the last resort because a fall is already in progress and workers will still be exposed to the force and possible trauma resulting from the fall itself.

Best Practices for Fall Protection

Most fall fatalities are preventable. By adhering to OSHA standards and best safety practices for fall protection, fall hazards can be eliminated or minimized to keep workers safe. Here are some best practices to ensure the effectiveness of fall protection.

- **Risk Assessment:** Conduct facility- and job-specific risk assessments to identify potential fall hazards and select the right fall protection system. Plan any high-risk O&M activities during facility shutdown to reduce impacts on product integrity.
- **Selection and Inspection:** The best type of fall protection is dependent on the type of activities and where the activities are being performed. When possible, prioritize passive protection such as fall prevention (e.g., guardrails) over an active protection (e.g., fall arrest/restraint) system. Per ANSI Z359.2-2023, a competent person should inspect each piece of fall protection equipment annually in accordance with the manufacturer's guidelines.
- **Maintenance:** Each part of a fall protection system needs regular maintenance to work effectively. All fall protection equipment should be cleaned regularly and dried properly to remove dirt and grime buildup and stored in cool dry places away from chemicals and heavy objects to extend the life of the equipment.
- **Training:** OSHA requires training for all workers who may be exposed to fall hazards, and this training must be documented and maintained (see 29 C.F.R. 1926.503).[5] Workers must demonstrate full understanding of potential fall hazards in the area and proper use and inspection of each piece of fall protection equipment prior to use.
- **Emergency Rescue Plan:** OSHA requires a written rescue plan for every location where fall protection is required. The plan must ensure prompt rescue of workers if/when they fall or that workers can rescue themselves.

Conclusion

Working at heights comes with great risks, sometimes even death, but with proper planning, inspection, maintenance, training, and rescue plans, these risks can be minimized or eliminated. Following OSHA standards and best practices for fall protection can help assure worker safety, and public well-being.

References and Additional Reading

1. U.S. Bureau of Labor Statistics. (2025, May). *Fatal falls in the construction industry in 2023.* U.S. Department of Labor. https://www.bls.gov/opub/ted/2025/fatal-falls-in-the-construction-industry-in-2023.htm
2. Duty to Have Fall Protection, 29 C.F.R. § 1926.501 (2025). https://www.ecfr.gov/current/title-29/subtitle-B/chapter-XVII/part-1926/subpart-M/section-1926.501
3. Duty to Have Fall Protection and Falling Object Protection, 29 C.F.R. § 1910.28 (2025). https://www.ecfr.gov/current/title-29/subtitle-B/chapter-XVII/part-1910/subpart-D/section-1910.28
4. Fall Protection Criteria and Practices, 29 C.F.R. § 1926.502 (2025). https://www.ecfr.gov/current/title-29/subtitle-B/chapter-XVII/part-1926/subpart-M/section-1926.502
5. Training Requirements, 29 C.F.R. § 1926.503 (2025). https://www.ecfr.gov/current/title-29/subtitle-B/chapter-XVII/part-1926/subpart-M/section-1926.503

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