Table S1: DOE Technical System Targets: Material Handling Equipment

STORAGE PARAMETER	UNITS	2015	2020
Hydrogen Capacity			
Hydrogen capacity	kg	2	2
System Volumetric Capacity			
Usable energy density from H_2 (net useful energy/max system volume) [b]	kWh/L (kg H_2/L system)	1.0 (0.03)	1.7 (0.05)
Storage System Cost			
System cost	$/kWh net ($/kg H_2 stored)	20 (667)	15 (500)
Durability/Operability			
External operating temperature range [c]	°C	-40/60	-40/60
Min/max delivery temperature [d]	°C	-40/85	-40/85
Operational cycle life (1/10 tank to full)	cycles	5,000 (5 yr)	10,000 (10 yr)
Min delivery pressure from storage system	bar (abs)	3	3
Max delivery pressure from storage system	bar (abs)	12	12
Shock and Vibration			
Shock	g	40	40
Vibration	g	5@10 Hz–0.75@200 Hz	10@10 Hz–1@200 Hz
Charging/Discharging Rates			
System fill time (2 kg)	min (kg H_2/min)	4.0 (0.5)	2.8 (0.7)
Minimum full flow rate	(g/s)/kW	0.02	0.02
Start time to full flow (20°C)	s	5	5
Start time to full flow (-20°C)	s	15	15
Transient response 10%–90% and 90%–0%	s	0.75	0.75
Fuel Purity			
Fuel purity (H_2 from storage) [e]	% H_2	SAE J2719 and ISO/PDTS 14687-2 (99.97% dry basis)	
Environmental Health and Safety			
Permeation and leakage [f]	–	Meets or exceeds applicable standards (e.g., CSA HPIT 1)	
Toxicity			
Safety			
Loss of usable H_2 [g]	(g/h)/kg $H_{2stored}$	0.1	0.05

[a] The targets are based on the lower heating value of hydrogen, without consideration of the conversion efficiency of the fuel cell power plant. Targets are for the complete hydrogen storage and delivery system, including tank, material, valves, regulators, piping, mounting brackets, insulation, added cooling or heating capacity, and/or other balance-of-plant components. All capacities are defined as usable capacities that could be delivered to the fuel cell power plant during normal use. All targets must be met at the end of service life. Since most applications of material handling equipment (MHE) require extra mass as a counterbalance, the system gravimetric capacity is not specified as it can vary widely among types of MHE.

However, system gravimetric capacity should be considered when developing hydrogen storage systems for MHE applications. All targets must be met at the end of service life.

[b] "Net useful energy" or "net" excludes unusable energy (i.e., hydrogen left in a tank below minimum fuel cell power plant pressure, flow, and temperature requirements) and hydrogen-derived energy used to extract the hydrogen from the storage medium (e.g., fuel used to heat a material to initiate or sustain hydrogen release).

[c] Stated ambient temperature. No allowable performance degradation from –20°C to 40°C. Allowable degradation outside these limits is to be determined.

[d] Delivery temperature refers to the inlet temperature of the hydrogen to the fuel cell.

[e] Hydrogen storage systems must be able to deliver hydrogen meeting acceptable hydrogen quality standards, such as CSA HPIT 1: Compressed Hydrogen Powered Industrial Trucks (forklifts) On-Board Fuel Storage and Handling Components. Note that some storage technologies may produce contaminants for which effects are unknown and not addressed by the published standards; these will be addressed by system engineering design on a case-by-case basis as more information becomes available.

[f] Total hydrogen lost into the environment as H2; relates to hydrogen accumulation in enclosed spaces. Storage system must comply with appropriate standards, for example CSA HPIT 1: Compressed Hydrogen Powered Industrial Trucks (forklifts) On-Board Fuel Storage and Handling Components. This includes any coating or enclosure that incorporates the envelope of the storage system.

[g] Total hydrogen lost from the storage system, including leaked or vented hydrogen; relates to loss of operational time.

Reference

https://www.energy.gov/eere/fuelcells/doe-technical-targets-hydrogen-storage-systems-material-handling-equipment