

APPENDIX A

BUS SPECIFICATIONS

SECTION A. GENERAL REQUIREMENTS

A.1 General

A.1.1 This Appendix provides the expected specifications for the two types of hydrogen fuel cell electric buses which are intended to be fueled at the hydrogen fueling station to be procured by this project. The estimated specifications are found in Table 1.

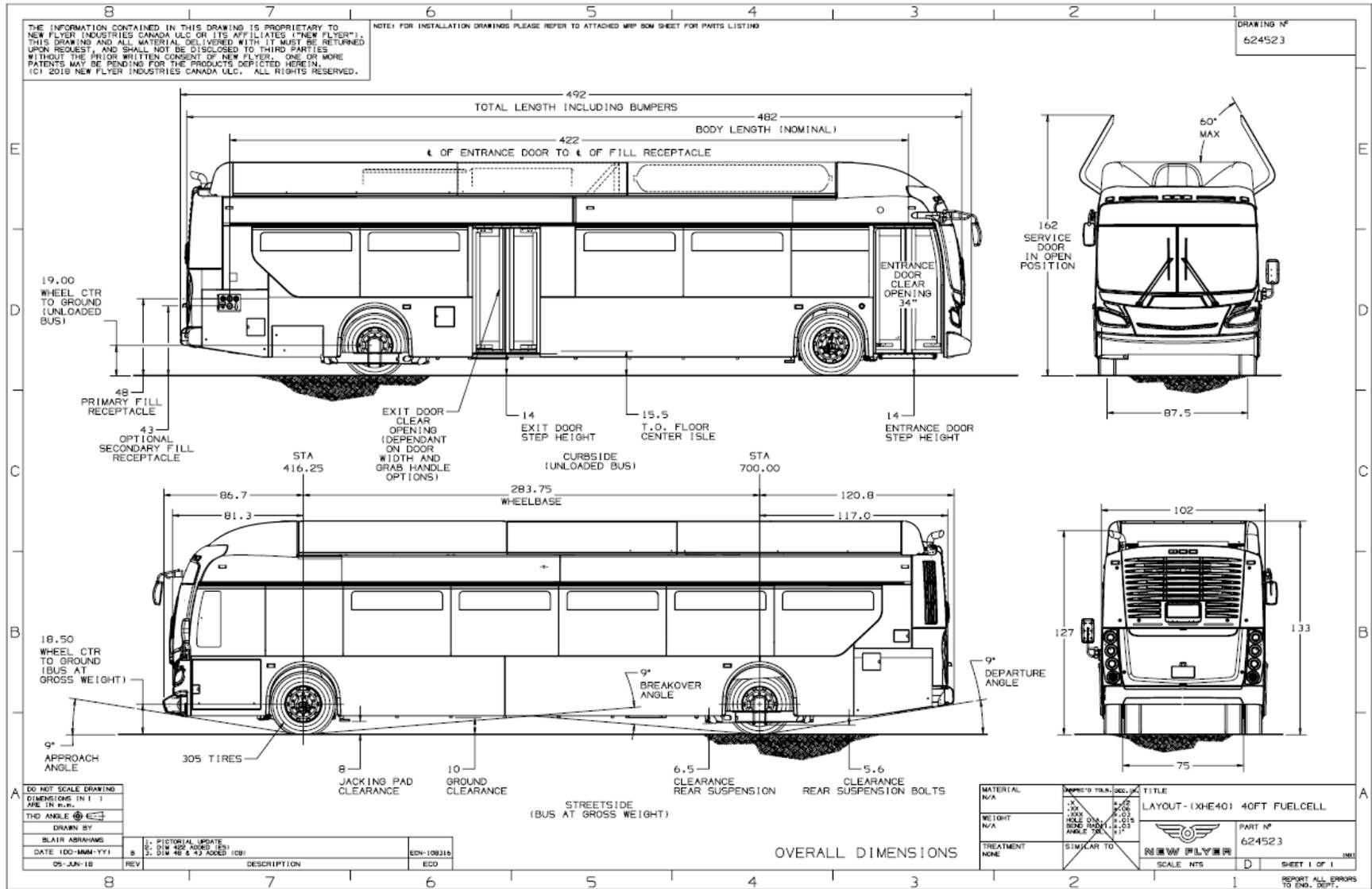
Table 1: Bus Specifications			
Specification Category	Specification	40' Bus	60' Bus
Bus	Model	New Flyer Xcelsior FC XHE40	New Flyer Xcelsior FC XHE60
	Curb Weight	15,195 kg	23,190
Storage	Number of On-Bard Gaseous Hydrogen Storage Cylinders (Tanks)	5	9
	Cylinder (Tank) Type Category	Type 4	Type 4
	Hydrogen Volume Per Tank	312 L	5 @ 312 L 4 @ 193 L
	Total Hydrogen Volume on Bus	1560 L	2332 L
	Hydrogen Mass Per Tank	7.5 kg	5 @ 7.5 kg 4 @ 4.625 kg
	Total Hydrogen Mass Stored on Bus	37.5 kg	56 kg
	Total Usable Hydrogen Mass on Bus	35.5 kg	53 kg
	Post Fueling Event Settled Pressure Target	35 MPa	35 Mpa
Fueling	Receptacle Type	TN 1 HF	TN 1 HF
	Nozzle Compatibility	TK 16 HF	TK 16 HF
	Station to Bus Communications Protocol	IrDA	IrDA

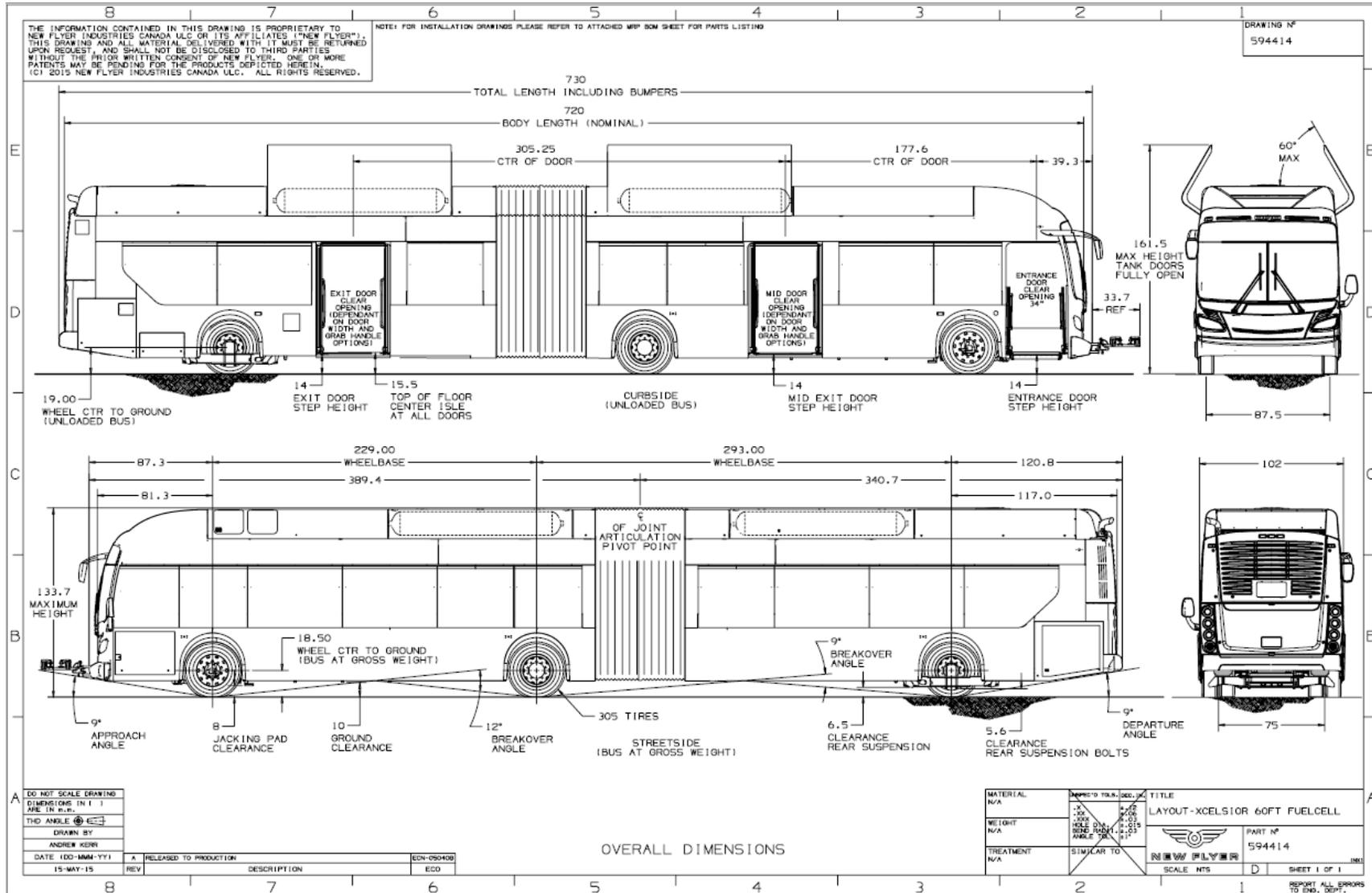
SECTION B. NEW FLYER XCELSIOR FC

B.1 General

- B.1.1** Any information presented are approximations only provided by the manufacturer for the purpose of planning only, and are not representative of the City of Winnipeg's Bus build. Contractor shall verify final vehicle information with New Flyer Industries during the design process

B.2 Drawings





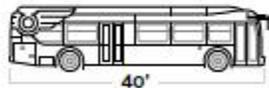
B.2.1 New Flyer Xcelsior FC Brochure



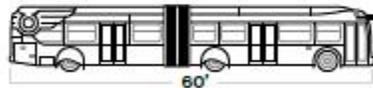
xcelsior CHARGE FC™
Our next generation, fuel cell-electric,
zero-emission transit bus.

Xcelsior CHARGE FC™ delivers longer range, better energy recovery and is smart city capable – making it the most advanced hydrogen fuel cell-electric bus in North America.

Available in 2 Lengths



40'



60'

Four distinct technology advancements to deliver a high-performance bus.



High-Power Batteries

The newest high-power, rapid-charge batteries.



Battery Packaging

Advanced protective battery packaging designed for easy installation and streamlined maintenance.



Fuel Cell Power Module

A new high-performing fuel cell power module that is simpler, more robust, and has a lower lifecycle cost.



Traction Propulsion System

A new lightweight electric traction propulsion system with up to 90% energy recovery.

Technology advancements.

1 Fuel cell power module.

FCmove™-HD+ is Ballard Power Systems' next generation heavy-duty fuel cell power module for zero-emission vehicle applications that introduces a more compact and robust design with substantial lifecycle cost reductions.

Reduced lifecycle cost is achieved through lower maintenance requirements, higher reliability, and fewer parts.

Simplified System Integration

- ✓ All subsystems are integrated into one enclosure.
- ✓ Easier to service and takes up less space on the bus.

Increased Reliability

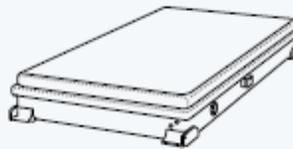
- ✓ Delivers >97% fuel cell power availability while in service.
- ✓ More robust components.
- ✓ With an IP69K rating, the module is 100% protected from intrusion of dust and water particles.

More Efficient

- ✓ Wide operating range across temperatures of -30°C (-22°F) to +50°C (122°F).
- ✓ Freeze start to -25°C (-13°F) without external energy or use of special start procedures.

2 Battery packaging.

A standardized waterproof battery enclosure is mounted on the rooftop using a "plug and play" approach, lending simplicity and efficiency in design, install, maintenance and manufacturing.



Rooftop application uses a modular approach with a simplified mounting system comprised of two rails running the length of the bus.

Simpler

- ✓ One simple and standardized approach for better quality, consistency, and accuracy.
- ✓ If a battery needs to be replaced, the module can be removed and replaced with a new/backup module. The module needing troubleshooting can be serviced in the shop while the bus with the new/backup module onboard returns to service.
- ✓ With every battery having the same enclosure, service manuals are the same for every single bus model and length.
- ✓ Service parts are reduced by 90% going from 250 to less than 50 parts.

Waterproof

- ✓ With an Ingress protection rating of IP67, the battery enclosure is 100% waterproof if submerged in water, which greatly reduces the likelihood of water leaking into the battery enclosure.
- ✓ With an Ingress protection rating of IP69K for dust, high temperatures, and high-pressure washing, there is 100% protection from intrusion of dust or water particles. This is ideal for demanding operating conditions, and situations where sanitization and rigorous cleaning is undertaken.

More Efficient

- ✓ Modules are better insulated resulting in better management of battery temperature for optimal performance.

Easier to Service

- ✓ The casings are built using a reinforced composite fiber that is non-conductive.
- ✓ Service technicians can simply and safely plug in or unplug the battery module with less exposure to high-voltage electricity.

Lighter

- ✓ The standardized battery enclosure is lighter in weight.

3 The newest high-power batteries.

The batteries are made of world-class energy storage systems (ESS), engineered for safe, robust, and reliable use in transit.

The battery chemistry is Lithium Nickel Manganese Cobalt (NMC), providing the best balance of energy, power, safety, and life.

More Energy

- ✓ 40% more energy available
- ✓ Greater capture of regenerative energy (during braking at top state of charge).

Extended Range

Range at highway speeds is extended by 44% without compromising quality.

More Efficient

Better controlled and more consistent cell temperature in high-demand applications.

4 High-grade Siemens traction system.

ELFA 3 is Siemens' next generation traction system that introduces a more efficient design with compact inverters and embedded drive controllers.

Safer

Easier and safer to maintain with shorter cable runs and touch-safe high voltage connections.

Smaller

Smaller and lighter, taking up less space on the bus.

More Efficient

- ✓ Minimal rack requiring no covers.
- ✓ Shorter cable runs offer decreased risk of issues or faults, improved electromagnetic compatibility (EMC) and greater power efficiency.
- ✓ Delivers up to 90% energy recuperation.
- ✓ Delivers smooth, quiet, emission-free driving (with no engine noise, no idling, and zero local emissions).
- ✓ Better torque accuracy.

Extended range with zero emissions.

New Flyer fuel cell technology is a unique and innovative way to obtain extended-range operation similar to existing transit vehicles using a fully zero-emission solution.



Robust Design

Built on the proven Xcelsior® platform, the Xcelsior CHARGE FC™ utilizes the same robust electric propulsion system as the Xcelsior CHARGE NG™ battery-electric bus, featuring industry-proven Siemens and ZF components.



Eco Friendly

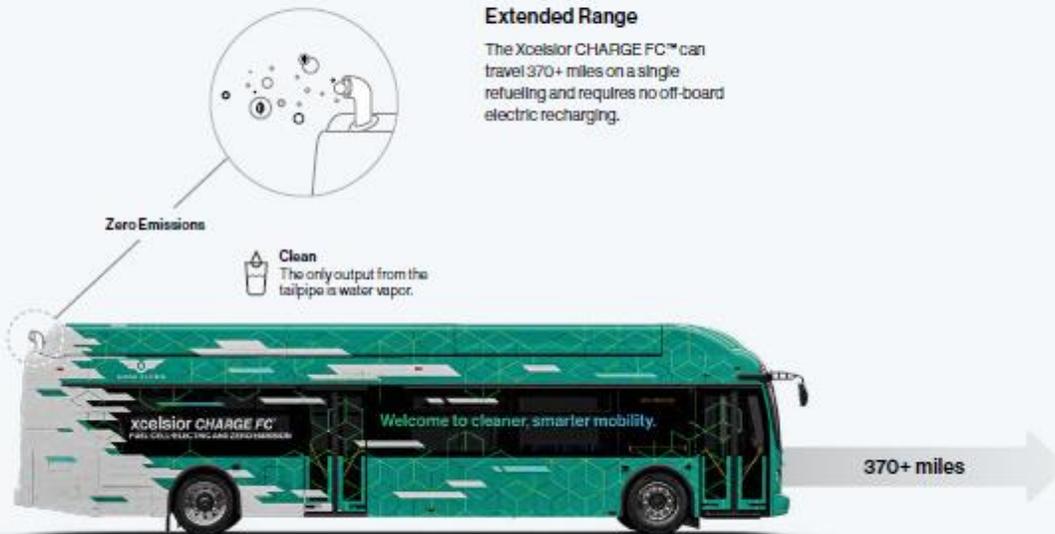
Hydrogen is clean, abundant, and can be reformed into hydrogen from natural gas (methane) or created from renewable sources such as wind or solar energy through electrolysis.

The Xcelsior CHARGE FC™ will avoid 85-135 tons of greenhouse gases per year from tailpipe emissions compared to a diesel bus.



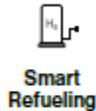
Extended Range

The Xcelsior CHARGE FC™ can travel 370+ miles on a single refueling and requires no off-board electric recharging.



How it works.

Xcelsior CHARGE FC™ is an electric vehicle that uses compressed hydrogen as an energy source.



What is a fuel cell? It is a device that converts chemical energy into electric energy.

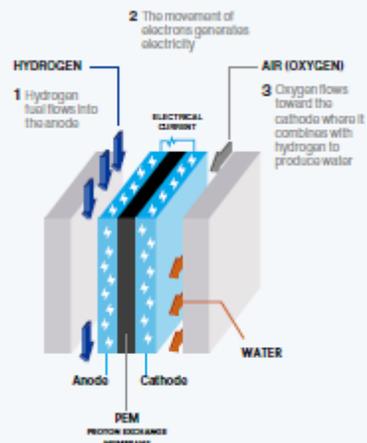
A series of chemical reactions splits hydrogen into protons and a current of electrons and then combines them with oxygen, which produces water. The flow of electrons is the electric current. The electric current is used to power the batteries and ultimately power the bus.

Fueling

40-foot: 6 - 10 min
60-foot: 12 - 20 min
*depending on operating conditions

Equipped with either or both T11 or T15 fill receptacles or a multi-fill port configuration. Receptacles can also be equipped with IR transmitters or hardwired communication ports to support fast filling at smart fill stations.

Lightweight Type 4 HGV2 tanks with 95% usable capacity.

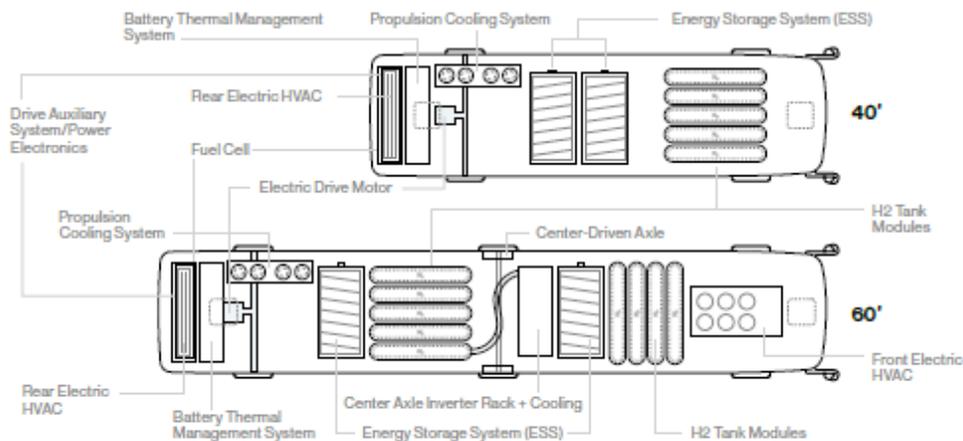


Technology

Fuel cell-electric buses combine the best of battery electric bus technology with an on-board power generator (fuel cell).

Fuel cell-electric buses use a battery-dominant hybrid architecture, where the batteries are large enough to handle all vehicle performance needs while the fuel cell acts like a continuous battery charger to extend the range of the vehicle.

newflyer.com/FC



Functionality + accessibility.



Kneeling

SmartRider™ enables kneeling to variable heights and minimizes the slope difference between a low-floor ramp and the bus floor.



Self-Leveling

SmartRider™ ramp achieves a 1:6 slope ratio with a self-leveling feature that can withstand up to 1000lbs.



Capacity

Industry-leading passenger carrying capacity with up to 82 total (40 seated and 42 standees).



CONNECT 360.

Connect 360™, operated by NFI Connect™, is a customizable performance dashboard that provides smart analytic reporting to expand insight and intelligence for managing your Xcelsior CHARGE FC™ fuel cell-electric bus.

Connect 360™ is included on every new Xcelsior CHARGE FC™. Learn more at nfigroup.com/connect



Additional range capability with improved driver performance.



Intelligence on how to preserve battery energy throughout the day.



Decision-making information to optimize charging strategies.



Reduced operating cost and maximum fleet utilization.



NFI Infrastructure Solutions™

NFI Infrastructure Solutions™ is a service dedicated to providing safe, reliable, smart and sustainable charging and mobility solutions.

Learn what Infrastructure Solutions can do for you at nfigroup.com/IS

What our Infrastructure Solutions team provides.

Supports mobility projects from start to finish.

Focuses on energy management optimization.

Provides Infrastructure planning and development.

Provides cohesive transition of bus fleets to zero-emission electric technology.

	40' XHE40	60' XHE60
Measurements		
Length	41' 0" (12.50m) over bumpers 40' 2" (12.24m) over body	60' 10" (18.54m) over bumpers 60' 0" (18.29m) over body
Width	102" (2.6m)	102" (2.6m)
Roof Height	11' 1" (3.3m)	11' 1" (3.3m)
Step Height	14" (361mm)	14" (361mm)
Front Step Height (Kneeled)	10" (254mm)	10" (254mm)
Interior Height – Floor to Ceiling	70" (2m) over front and rear axle; 66" (2.4m) mid-coach	70" (2m) over front and rear axle; 66" (2.4m) mid-coach
Tire Size	30s/70R22.5	30s/70R22.5
Wheelbase	283.75" (7.2m)	220" (5.6m) front / 203" (7.4m) rear
Propulsion		
Motor	Siemens Electric Drive System Optional High Gradability Motor	Siemens Electric Drive System ZF AVE130 In-Wheel Motor Center Drive Axle Optional High Gradability Motor
Rated Power	160 kW	320 kW
Rated Torque (*Based on 1:5.67 ratio axle)	1,033 lb-ft	2,066 lb-ft
Passenger Capacity (*Based on 160kWh ESS configuration)		
Seats	Up to 40*	Up to 52 (with one exit door)*
Standees	Up to 42*	Up to 73 (with one exit door)*
Accessibility		
Doors	2	2 or 3 (option for up to 5 doors)
Wheelchair Accessibility	32" (813mm) wide, 1:6 slope Flip out NFIL ramp, front door	32" (813mm) wide, 1:6 slope Flip out NFIL ramp, front door
Wheelchair Locations	2 - front location, rear location also available (other options available)	2 - front location, rear location also available (other options available)
Approach Angle		
Approach/Departure/Breakover Angles	9°/9°/9°	9°/9°/12° (front) 9° (back)
Turning Radius (Body, with aluminum wheels; *varies with wheel type)		
Turning Radius	43.5' (13.3)*	42' (12.8m)*
Main Components		
Floor	Marine Grade Plywood Floor Optional Composite Floor Composite Rear Interior Slap Tarabus, Altro, RCA Floor Covering	Marine Grade Plywood Floor Optional Composite Floor Composite Rear Interior Slap Tarabus, Altro, RCA Floor Covering
Electrical System	Parker Vansco	Parker Vansco
Cooling System	Electric cooling fans	Electric cooling fans
HVAC	Thermo King TE-16 (rear)	Thermo King RLFE (front) TE-16 (rear)
Axles	MAN VOK 07 front disc brakes MAN HY-1350 rear disc brakes, single reduction axle	MAN VOK 07 front disc brakes, ZF AVE 130 center disc brake MAN HY-1350 rear disc brakes, single reduction axle
Energy Storage System		
Fuel Cell	Ballard Power Systems FCmove™-HD+	Ballard Power Systems FCmove™-HD+
Equivalent Battery Energy	734 kWh base configuration	Up to 1000 kWh
Hydrogen Storage Capacity	37.5 kg (base)	56 kg
Net Power	100 kW	100 kW

B.4 Pressure Drop Analysis

B.4.1 Hydrogen Fuel Storage System (HFSS) Fuel Fill Pressure Drop Estimate Analysis



**NPD507
XHE40 & XHE60 Pressure Drop Estimate vs. Air Supply Requirement
V4**

Hydrogen Fuel Storage System (HFSS) Fuel Fill Pressure Drop Estimate Analysis

By: Steven Young & Klaas Vonck

Date: 6/13/2023



Executive Summary

This report evaluated the pressure drop of the NF XHE60 and XHE40 H2 fill lines with and without the Pony tanks against the requirements from Air Supply, a fill station supplier (300 psi max drop at 100 g/s (6kg/min) flow)

Results:

- XHE40 without Pony tanks 451 psi pressure drop
- XHE40 with Pony tanks 280 psi pressure drop
- XHE60 without Pony tanks drop (For Ref Only) 451 psi pressure drop (For Ref Only)
- XHE60 with Pony tanks 410 psi pressure drop

Details of the Ask:

From: Cooke, Erin <ECooke@winnipeg.ca>
Sent: Friday, May 5, 2023 9:53 AM
To: Funk, Edgar <efunk@winnipeg.ca>
Subject: RFP for hydrogen station.

Hi Edgar,

I'm working with CTE on the RFP for our hydrogen station. New Flyer has previously provided us two pressure drop analysis reports to assist with the development of the technical specification. Neither of these documents were created directly for Winnipeg Transit. We wanted confirmation that the information is in fact reflective of WT's build. After yesterday's email I'm confident that the XHE60 is accurate, but if we are adding the extra tanks to the XHE 40 (which I would recommend cost dependent) we would need an updated pressure drop analysis.

Also CTE is wondering whether it would be possible to attach a pressure drop report in the RFP for the hydrogen station. There is clearly some information in these reports that New Flyer would want to keep confidential, but I'm wondering if it might be possible for New Flyer to create a Winnipeg specific document compiling the information from these two documents into one with any confidential information redacted.

If possible we would need a revised document by mid-June to be able to include it in the RFP.

If not, as they feel the entire document confidential, I will just tell CTE they can't include it.

I'm assuming any requests should now go through you to Dawn, and not from me to Dawn, Adrian or Chad directly, so I was hoping you could forward this on my behalf.

Regards,



Erin Cooke
Project Manager - Transition to Zero Emission Bus Program

Winnipeg Transit
Asset Management Office

Telephone: 204-226-3557

Email: ecooke@winnipeg.ca

Website: winnipeg.ca

Address: 414A Osborne Street, Winnipeg, MB R3L 2A1

Hydrogen Fuel Storage System Analysis Details

Background / Purpose

- SAE J2601-2 states and requires that:
 - *"Different HDHSV CHSS will have a range of pressure drops across the system."*
 - *"The maximum expected pressure drop across the vehicle from receptacle/nozzle coupling to tanks should be designed to be as minimal as possible."*
- Simulate pressure drop across boundary from receptacle(s) to tanks.
- Assist fill station integrator in understanding the coach side fuel system plumbing.

Simulation

- Software: Flow of Fluids v17.2.50998
- Estimation using Darcy-Weisbach analysis.
- System pressure drop (dP) between 10% - 40% (~ 15% - 27%)
- Fluid properties were varied through the system for pressure to be within 10% or less of condition.
 - Inlet pressure, $P_N = 2,000$ psi g
 - Fluid Temp., $T = 0$ °C

References

- Technical Paper 410M, 04/2013 (Crane)
- Introduction to Fluid Mechanics 4th Ed. (Fox, McDonald)
- J2601-2 Fueling Protocol for Gaseous Hydrogen Powered Heavy Duty Vehicles, 09/2014 (SAE)

Assumptions

- TN5 Receptacle is used
- System pressure drop of ≤ 300 psi g is desired by fill station integrator.
- Target flow mass flow rate, m of 6 kg/min (100 g/sec).
- SAE J2601-2 "Fast Fueling Option "A" : 3.6 kg/min $< m \leq 7.2$ kg/min
- Temperature drop upstream to downstream is not considered.

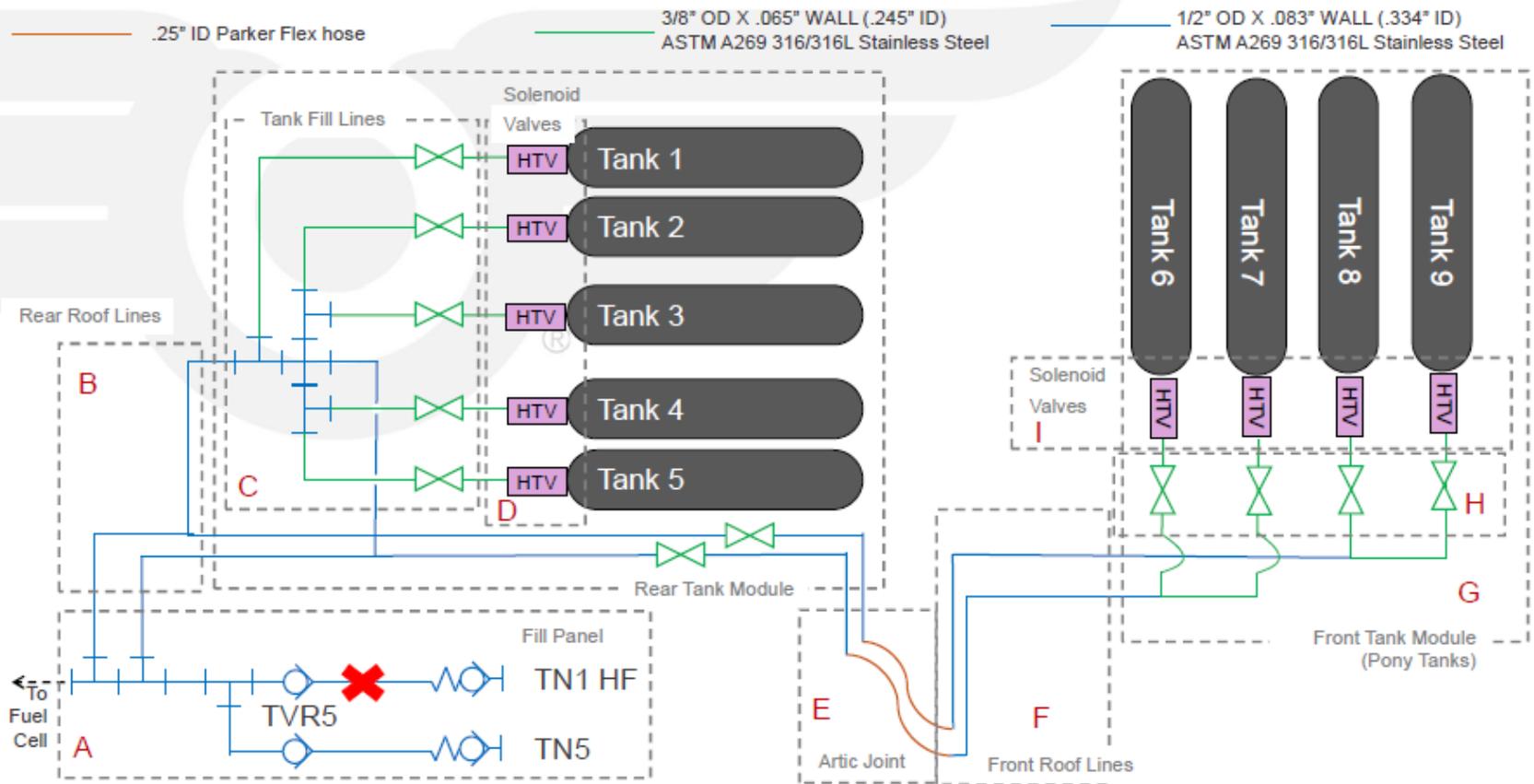
Disclaimer

- Design analyzed is currently in process & future design changes may affect reported results. The analysis included is of a concept (un-released) design as per the date on this report.

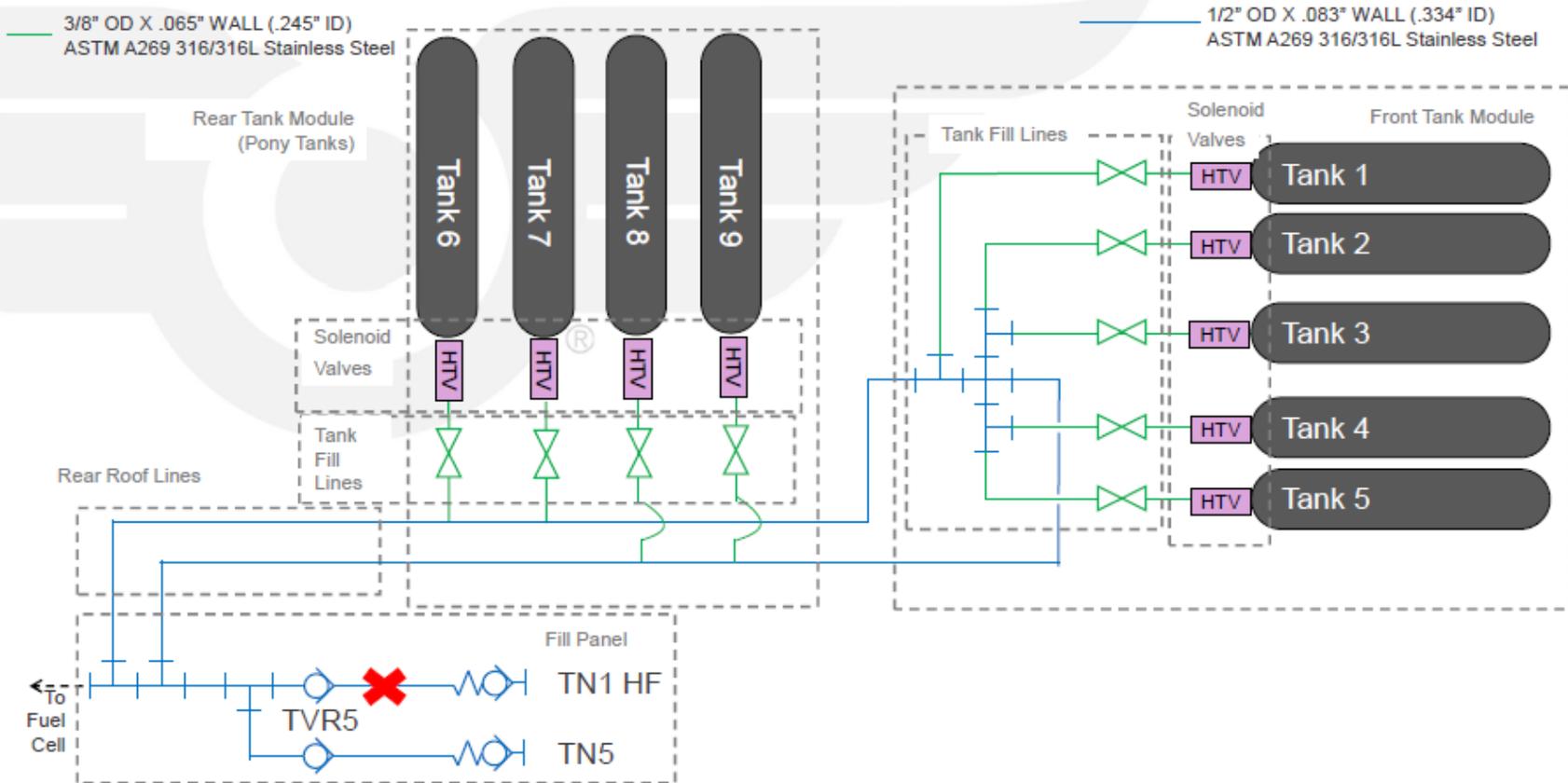
Results

FC Move w ELFA 3: Description of Schematic:	XHE40		XHE60:	
	Without Pony Tank	With Pony Tank	Without Pony Tank (Ref only)	With Pony Tank
Total Flow (kg/min)	6	6	6	6
Flow Per Tank: (kg/min)	1.2	0.67	1.2	0.67
Inlet Pressure:	2000	2000	2000	2000
Tank 1	1549	1720	1549	1702
Tank 2	1556	1722	1555	1704
Tank 3	1559	1723	1558	1705
Tank 4	1549	1720	1549	1702
Tank 5	1556	1722	1555	1704
Tank 6	N/A	1732	N/A	1590
Tank 7	N/A	1730	N/A	1590
Tank 8	N/A	1736	N/A	1591
Tank 9	N/A	1733	N/A	1590
Total Pressure drop:	451	280	451	410
Difference from Req (300 psi):	-151	20	-151	-110
% Difference From Req.:	-50%	7%	-50%	-37%

System Schematic – Fill Path – ELFA 3 XHE60 Production Intent w Pony Tank



System Schematic – Fill Path – ELFA 3 XHE40 Production Intent with Pony Tank



System Schematic – Fill Path – ELFA 3 XHE40 Production Intent without Pony Tank

