Fire Apparatus Capital Equipment Recycling

National Indigenous Fire Safety Council Project (NIFSC)

November 2021

FINAL REPORT

National Indigenous
Fire Safety Council Project
Projet du conseil national
autochtone de la sécurité-incendie

Aboriginal Firefighters Association of Canada
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Submitted by:

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Fire Apparatus
Capital Equipment Recycling

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I: Project Overview

Background

The National Indigenous Fire Safety Council (NIFSC) Project National Indigenous Fire Safety Council Project (NIFSC) being undertaken by the Aboriginal Firefighters Association of Canada (AFAC) to support the development of community capacity for safer and healthy Indigenous communities.

The project has the following objectives to serve the goal of building healthy and safe Indigenous communities:

- Secure new funding for required capacity to develop and operate the NIFSC.
- Collaborate with existing Indigenous fire and emergency services.
- Engage with Indigenous communities to help define the NIFSC.
- Design programs and services to build and maintain capacity within Indigenous communities.
- Address identified gaps in Indigenous fire service.

Objective

Create a policy document to guide apparatus replacement, specification alternatives, and criteria for extending the serviceable and credited life of apparatus.

Scope of Work

The project will result in a systematic review of existing fire apparatus requirements, rationale, and evaluation of compliance mechanisms with insurance industry guidance and best practices. In addition, the report will review maintenance requirements for extending the useful life of apparatus in accordance with insurance industry guidelines.

The report will also evaluate potential alternatives to existing guidance for apparatus requirements to consider alternate apparatus technologies. Finally, the report will evaluate alternate protections in the built environment as a means to reduce fire risk.

Project Team

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Manitou, Inc. Project Team
Project Lead

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Alternative Fire Apparatus

John L. Cochran,
Fire Underwriters Survey and Apparatus Requirements

Timeline and Deliverables

Timeline. Project initiation within 15 days of receipt of Statement of Work and return of executed agreement. It is expected that work will be completed in 4 months.

Deliverables. The project team to develop:

1. A comprehensive policy report addressing:

    a. Current insurance industry guidelines (Fire Underwriter's Survey) for necessary fire flows and required pumping capacity and ancillary apparatus.

    b. Replacement cycles and extended life for apparatus, including necessary maintenance and other requirements.

    c. Evaluate risk-informed alternative approaches to include:

        - Fire Underwriters' Survey Alternatives including non-traditional apparatus
        - Built Environment Alternatives/Mitigation Strategies
        - Provide a methodology for assessing current apparatus condition for use by NIFSC staff.

2. The team will deliver a draft report along with tables and or charts outline that are easy to follow

3. The team will incorporate or reflect comments or corrections provided by the client for delivery of a final report.

Throughout the document, we reference numerous standards. Reference does not imply endorsement, and the reader is referred to the actual standard for definitive guidance. We quote and reference such standards throughout the text as an aid to explanation, not for purposes of ensuring compliance. Units are expressed in SI, Imperial, and US measures within the report.

Acknowledgements

The authors would like to acknowledge the National Indigenous Fire Safety Council for requesting this work and being committed to evidence-based decision-making in such critical areas of community health. In particular, the researcher thanks the Board of Directors, Blaine Wiggins, Executive Director, Len Garis, Director of Research, Mandy Desautels Director of Strategic Initiatives and Ameena Sadique, Project Manager, for their vision and guidance as the project unfolded.

II: Influences on Fire Apparatus

Fire Underwriters Survey

Throughout Canada the most common influence on the design and specifications of structural fire apparatus are standards and performance criteria of the Fire Underwriters Survey. The FUS is a national organization that provides data on public fire protection for insurance statistical work and underwriting purposes to subscribing private sector property and casualty fire insurers. Much of the organization's work includes evaluating community fire defenses in the prevention and mitigation of local fire risks. These evaluations are comprehensive and include an assessment of the municipal fire department including the type, performance and condition of fire apparatus in use. FUS publishes its information through the **Public Fire Protection Classification** (PFPC) and **Dwelling Protection Grades** (DPG) insurance grading systems.

Across the country communities the PFPC and the DPG are applied by FUS fire protection specialist who periodically conducted onsite survey of local fire defenses. In turn, their findings are then published in the Fire Insurance Grading Index. The index is referenced by subscribing insurers to determine when setting fire insurance rates for a community's commercial and residential properties.

It is a major incentive by community leaders to support improvements local fire defenses in order to obtain reduced classifications published by the FUS. Improvements in the PFPC or DPG may present potential reduced fire insurance rates for commercial and dwelling property owners. It is important to mention that every insurance company has its own proprietary methods and formulas for calculating fire insurance rates. Regardless, the PFPC and DPG classifications can be very useful to insurers in determining the level of insurable fire risks found within a community.

The FUS Grading Schedule. During the early 1900s fire engineering analysis conducted by the US-based National Board of Fire Underwriters in concert with the Canadian Fire Underwriters Association, the predecessor of the FUS, was utilized in the development of the original "Standard Schedule for Grading Cities and Towns with Reference to their Fire Defenses". The schedule, or standard, laid the foundation for the process and methodology that is applied in today's Public Fire Protection Classification and Dwelling Protection Grades when measuring public fire defenses and fire and associated risks.

The document has been modified and updated several times over the years in order to reflect the changing character of communities and advances in public fire protection. The current title of the schedule is the **Classification Standard for Public Fire Protection** (CSPFP). The Classification Standard addresses the level of risk present within the community as compared to the availability and reliability of water systems, the fire department prevention, mitigation and response capabilities, and other direct or indirect elements of the local fire defense system. It is not uncommon for fire chiefs and municipal administrators to include the Classification Standard as a guide when developing a master plan for community fire defenses.

As will be discussed later in greater detail, the CSPFP references nationally recognized standards, including those related to the specifications of fire apparatus, published by the National Fire Protection Association. FUS fire protection specialists apply the Classification Standard when assigning the PFPC and DPG classifications to communities.

It is important to note the type, number of, and condition of fire apparatus is a significant factor in establishing the community's fire protection classification and dwelling grade. As an example, the type of apparatus in service should be matched with the severity of the local fire risk. A single small capacity pumper may insufficient in a community with several miles of older multistory factory buildings. In this scenario, several high-capacity pumpers strategically located across the city may be more efficient and their presence may result in a lower fire insurance classification.

Required Fire Flow. When applying the Classification Standard, FUS fire protection specialist reviews the community's level of fire risk. Every community is unique in its layout, age and condition of buildings that may pose a level of fire risk, either to the occupants or property within the building, or those that are adjacent. Adjacent buildings are often referred to as exposures. The FUS gives each insured building within the community a Required Fire Flow (RFF) rating. The culmination of these RFF ratings serves as the bedrock for the community's final insurance grading serving as the benchmark for the performance of the water system and the organization of the fire department including the number of fire stations needed and their assigned staffing and apparatus.

A building's required flow is a calculated amount of water needed to effectively suppress a building that is fully involved with fire. A required flow takes into account many factors such as the building's construction type, occupancy, square meters, number of stories, and distance from exposures, or other structures. The FUS considers the required fire flows of buildings when grading aa community's public fire protection classification and dwelling protection gradings.

The FUS defines a required fire flow as the rate of water flow, at a residual pressure of 20 psi (150 kPa) and for a specified duration that is necessary to control a major fire in a specific building or grouping of structures utilizing manual firefighting measure in conjunction with built-in safety features of a building. The FUS records the required fire flows of most insured commercial properties within each community. Fire flows will vary throughout a community due to the variety of factors including:

Construction Type. The FUS applies one or a combination of the following construction types:

Type V – Wood Frame
Type IV – Heavy Timber
Type III – Ordinary
Type II – Non-combustible
Type I – Fire Resistive

Occupancy. A building's occupancy is considered based on the severity of the content's fire hazard factor.

Effective Building Area. The total effective area is the floor with the greatest square meters plus percentages of area of other floors based on construction type and protection of vertical openings.

Height. Consideration is given to single story buildings that are 10 feet (3 m) in height base on the occupancy classification and commodities.

Compartmentation. Portions of a building that is equipped with an approved vertical firewall with a fire-resistance rating of not less than 2-hours that meet the requirements of the National Building Code may be calculated as separate required fire flow areas.

Protection. The required fire flow may be reduced by as much as 50% if the building is equipped with an approved automatic fire sprinkler. To receive full benefit of this reduction, the system must meet all of the design and installation, water supply, supervision and inspection of the system.

Exposures. Adjacent buildings and other properties that present an exposure fire hazard are factored based on the separation their distance to the structure. No exposure charge is applied if there are 30 meters or more between structures.

It is important for fire departments to be aware of the fire flows of buildings within the community it protects. The major elements that make up a community fire defense system are based on these required fire flows. For example, the municipal water system and its array of reservoirs and pumping stations, network of mains and the distribution of fire hydrant should be designed, at least in part, on the required fire flows found various areas of community protected. As important is the volume and pressures associated with these required flows. Another example related to fire apparatus specifications is the number of pumpers needed within a community and their rated pump capacities.

A more detailed overview of the RFF methodology and calculation process can be reviewed in the guide *"Water Supply for Public Fire Protectio*n," which can be found on the FUS website.

Public Fire Protection Classifications. A community's Public Fire Protection Classification rating is expressed on a 1 to 10 scale. Commercial insurers recognize these classifications as "town grades". Class 1 represents the "ideal" or highest level of public fire protection while Class 10 reflects the absence of any effective public fire protection. The Grades indicate how well the different components of a community's fire defenses collectively are prepared to control major fires that may be expected to occur in commercial, industrial, institutional and multi-family residential properties and are developed from a comprehensive review of all facets of the fire defense system as it relates to the level of risk present within the community. Various elements of each component of the fire defense system, such as fire apparatus, are awarded credit, or points, for their performance. Fire apparatus design and condition play a significant role in determining a community's final grading. A community's grading is broken down into the following four major components:

Table 2.1 – Public Fire Protection Classification Components

Component	% of Final Grading
Fire Department	40%
Water Supply	30%
Fire Prevention and Fire Safety Control	10%
Emergency Communications	10%
Total	100%

Fire Department – 40% of Overall Grading. A detailed breakdown of the Fire Department component includes the following areas of review:

- Type and number of fire apparatus
- The condition and age of fire apparatus and equipment
- Pumper apparatus pump capacity
- The type of staffing (i.e., career Firefighters vs. paid-on-call)
- The distribution of companies relative to fire risk
- Response to alarm protocols
- Management of emergency services
- Training programs and pre-incident planning

As can be seen, the first three areas address fire department's apparatus and equipment.

The Type and Number of Fire Apparatus. This is assessed in relation to the severity of local conditions such as the amount of water needed to suppress structure fires expressed in gallons per minute (gpm/Lmin) and the pump capacity of fire department pumpers. The number of pumpers needed and their pump capacity is corelated to the gpm/Lmin needed to suppression a fire in a structure. The amount of water needed to suppress a fire is expressed as a structure's needed fire flow (NFF).

The Condition and Age of Fire Apparatus and Equipment. Each credited apparatus is evaluated in accordance with minimum design and performance standards. The condition of pumper apparatus is evaluated with regard to its chassis, engine, drivetrain, pump, ground ladders and equipment. Similarly, a ladder truck will be credited in the same way, the exception being the added evaluation of the aerial ladder or similar device. The age of an apparatus is also a factor and will be further discussed later in this section.

Pumper Apparatus Pump Capacity. Apparatus equipped with a pump are evaluated with regards to the pump's capabilities to meet its listed capacity of pressures and gallons per minute under to adverse pumping conditions. To simulate these conditions, the pump must perform at optimum capacity under draft for a specified period of time.

Under the Classification Standard, fire apparatus is assessed based on the most recent edition of the National Fire Protection Association's Standard 1901, Standard for Automotive Fire Apparatus in conjunction with Standard for Automobile Firefighting Apparatus, CAN/ULC-

S515-13-R2018, as published by the Standards Council of Canada and the Underwriters Laboratories of Canada. Further explanation of the standards will be addressed in Section 3 including a description of each recognized apparatus, their specifications and credit the fire department may earn that may be earned with regards to apparatus age, performance and condition when being graded under the Public Fire Protection Classification (PFPC) and Dwelling Protection Grades (DPG) grading systems.

Water Supply – 30% of Overall Grading. The adequacy of the water system plays a part within the community's fire defense system. To be considered adequate, the system should be able to deliver the estimated **Basic Fire Flow** that is based on calculations of the Needed Fire Flow of the community's fire risks while simultaneously providing domestic water service under maximum conditions. The following list provides a general overview of the areas of the water system reviewed:

- Water sources
- Purification process
- System capability and reliability
- Storage
- Pumps
- Mains and fire hydrants

Alternative Water Supply and Tankers. In rural areas where there is no recognized municipal water system, tanker apparatus in conjunction with reliable alternative water sources may be credited as a water supply. Alternative water sources can be ponds or lakes, streams, static water reservoirs such as tanks or cisterns. Very often, alternative sources such as ponds will be equipped with a dry hydrant for fire department drafting purposes. To receive credit, the fire department must show proficiency in water shuttling operations through a combined use of pumpers, tankers, portable ponds and drafting operations.

Fire Prevention and Fire Safety Control – 20% of Overall Grading. Though maybe at times not as exciting as conventional firefighting, proactive fire prevention and mitigation programs can greatly contribute to the overall control of community fire risks and subsequent savings in fire insurance premiums. In other words, the community has more than one approach to improving its PFPC and DPG gradings. The Classification Standard addresses fire prevention in the following areas:

- Code and standard adoption
- Code enforcement
- Inspections
- Permitting
- Plans review
- Public education and advisory services
- Fire investigation

Emergency Communications – 10% of Overall Grading. The community's emergency communications operation serves as the fire department's nerve center. The center is assessed is assessed with regards to the flowing criteria:

- Facilities
- Computer-aided dispatch and related equipment
- Staffing and qualifications
- Call processing and volume
- Dispatch circuits

Dwelling Protection Grade. Similar to the Public Fire Protection Classifications, but focused solely on detached one- and two-family dwellings, the DPG is a numerical system scaled from 1-5 with 1 being the highest grade possible and 5 indicating little or no recognized public fire protection. The DPG provides an approximate measure of the fire defense capabilities of a community with respect to providing structural fire response to typical detached dwellings. The system addresses a community's water system, fire department and the community's Public Fire Protection Classification.

Insurers apply a community's DPG grading when calculating appropriate insurance rates/premiums for one- and two-family dwellings. A more detailed description of the DPG system can be found on the FUS website. Table 2.2 provides a further breakdown of each of the grading levels.

Specific criteria include:

- The Dwelling Protection Grade System provides an approximate measure of the fire defense capabilities of a community with respect to providing structural fire response to typical detached dwellings.

- Recognized response distances are limited to 8km by road of continuously accessible (and appropriately maintained) public roads. Response from within 5km by road is preferred due to reduction in response times. Private roads may be recognized where evidence of maintenance reliability is evaluated and accepted by Fire Underwriters Survey.

- Response times are expected to be delayed to varying degrees in cases where volunteer fire fighters are responding due to the increased turn-out time as compared to on-duty fire fighters that respond directly from the Emergency Response Facility (fire station).

- Fire departments desiring fire insurance grading recognition should be organized on a sound financial basis such as a tax levy. Areas organized on a society or subscription basis will not be recognized because of the difficulty in identifying residents within the protected area who are current members of the society and the lack of guaranteed funds to adequately finance a fire department year-round.

With regards to a fire department's apparatus, the following provides an overview of the requirements for grading level:

Grades 1 through 3-A

- For each fire hall with a Dwelling Protection Grade 1 through 3-A, fire apparatus must include a minimum of one triple combination pumper rated at not less than 3000 LPM (750 gpm (US) at 150 psi and designed in accordance with:
  - Underwriters' Laboratories of Canada (ULC) S515 Automobile Fire Fighting Apparatus, or
  - National Fire Protection Association (NFPA) 1901 Standard for Automotive Fire Apparatus
- Credit for fire apparatus will be based on evidence of reliability indicators including the listing of apparatus by ULC, design specifications, fire pump service test records, age, maintenance history, etc. Apparatus is evaluated from the perspective of the capacity to provide structural fire protection.
- To be credited, apparatus must be stored in a suitably constructed and arranged fire hall.

Grade 3-B

- For each fire hall with a Dwelling Protection Grade 3B, fire apparatus must include:
  - a minimum of one triple combination pumper rated at not less than 3000 LPM (750 gpm at 150 psi), AND
  - a minimum of one mobile water supply apparatus with:
  - a minimum rated water carrying capacity of 4000 L (1000 gal (US)), AND
- For full credit apparatus must be designed in accordance with:
  - Underwriters' Laboratories of Canada (ULC) S515 Automobile Fire Fighting Apparatus, or
  - National Fire Protection Association (NFPA) 1901 Standard for Automotive Fire Apparatus
- In addition, the combined water carrying capacity of the 2 units (noted above) must be at least 1750 gal (US) total and the fire department must have a transfer system capable of supplying the pumper with water as needed. This may be accomplished by pump or dump valve to a portable tank of at least 4550 Litres (1000 gal (US)) capacity.
- Credit for fire apparatus will be based on evidence of reliability indicators including the listing of apparatus by ULC, design specifications, fire pump service test records, age, maintenance history, etc. Apparatus is evaluated from the perspective of the capacity to provide structural fire protection.
- To be credited, apparatus must be stored in a suitably constructed and arranged fire hall.

Table 2.2 – Dwelling Protection Grades - Minimum Requirements per Fire Station

Dwelling Protection Grade (DPG)	Water Works System	Fire Department		Public Fire Protection Classification (PFPC) [2] Minimum Requirements
		Apparatus	Firefighters	
1	Water supply system designed in accordance with Fire Underwriters Survey standard "Water Supply for Public Fire Protection" with a relative classification of 5 or better	Response from within 8 km by road of a triple combination pumper	Minimum Response: • On-duty: 3 career fire fighters, plus • Off-duty: fire chief or other officer	Water Supply and Fire Department must grade PFPC Relative Class 5 or better
2	Water supply system designed in accordance with Fire Underwriters Survey standard "Water Supply for Public Fire Protection" with a relative classification of 6 or better	Response from within 8 km by road of a triple combination pumper	Minimum Response: • On-duty: 1 career fire fighter, plus • Off-duty: fire chief or other officer • On-call: 15 auxiliary fire fighters	Water Supply and Fire Department must grade PFPC Relative Class 6 or better
3A	Water supply system designed in accordance with, and meeting the minimum requirements of, Fire Underwriters Survey "Water Supply for Public Fire Protection"	Response from within 8 km by road of a triple combination pumper	15 auxiliary fire fighters	No Public Fire Protection Classification required
3B	Not required - however fire department must have adequate equipment, training and access to approved water supplies to deliver standard shuttle service in accordance with NFPA 1142, Standard on Water Supplies for Suburban and Rural Fire Fighting	2 units required. Triple combination pumper plus a mobile water supply with a combined water carrying capacity of not less than 6820 L (1500 IG)	15 auxiliary fire fighters	No Public Fire Protection Classification required
4 [3]	Not required - however fire department must have adequate equipment, training and access to approved water supplies to deliver shuttle service in accordance with NFPA 1142, Standard on Water Supplies for Suburban and Rural Fire Fighting	2 units required. Triple combination pumper plus a mobile water supply with a combined water carrying capacity of not less than 6820 L (1500 IG)	15 auxiliary fire fighters	No Public Fire Protection Classification required
5	Unprotected communities or communities not qualifying for Grades 1, 2, 3A, 3B, or 4 above	Unprotected communities or communities not qualifying for Grades 1, 2, 3A, 3B, or 4 above	Unprotected communities or communities not qualifying for Grades 1, 2, 3A, 3B, or 4 above	No Public Fire Protection Classification required

[1] Refer to additional notes and requirements for interpretation

[2] The P.F.P.C. is a sophisticated municipal fire protection grading system utilized for Commercial Lines insurance. PFPC fire insurance grades are scaled from 1 to 10. One (1) represents a high level of fire protection and 10 indicates little or no recognized fire protection. This system evaluates the ability of a community's fire defenses to prevent and control major fires that may occur in commercial, industrial and institutional buildings and/or districts.

[3] Dwelling Protection Grade 4 is reserved for communities that contract for fire protection services from fire service agencies with a Dwelling Protection Grade of 3B.

Requirements for Dwelling Protection Grade 4 are the same as for Dwelling Protection Grade 3B, however in some cases, an allowance may be considered for Dwelling Protection Grade 4 where all of the criteria for Dwelling Protection Grade 3B have been met with one exception. If more than one criterion has not been met (ex. less than 15 auxiliary fire fighters and a single pumper apparatus) Dwelling Protection Grade 5 is applied.

Where Dwelling Protection Grade 4 is applied, a signed letter of intent from the community is to be sent to Fire Underwriters Survey indicating that improvements will be made, within an agreed timeframe, to meet the criteria of Dwelling Protection Grade 3B.

It is important to note that the absolute minimum number of auxiliary fire fighters considered within the fire insurance grading is 10 and that maximum age of apparatus that can be considered is 30.

Grade 4

- Dwelling Protection Grade 4 is reserved for communities that contract for fire protection services from fire service agencies with a Dwelling Protection Grade of 3B.
- Requirements for Dwelling Protection Grade 4 are the same as for Dwelling Protection Grade 3B, however in some cases, an allowance may be considered for Dwelling Protection Grade 4 where all of the criteria for Dwelling Protection Grade 3B have been met with one exception.

Grade 5

No recognized fire protection provided; community does not qualify for Dwelling Protection Grading.

III: Apparatus Design Standards and Guidelines

Fire apparatus manufactured in North America must meet minimum design criteria in order to be recognized by the fire insurance industry, municipal officials and those that oversee firefighting and rescue operations as well as firefighter safety. For years the fire protection community has established minimum criteria have established a common framework whereby most apparatus are uniformly designed with regards to performance and functionality.

The criteria are set forth within recognized standards of the National Fire Protection Association and those of the Underwriters Laboratories of Canada and the Standards Council of Canada.

Probably the most influential fire protection organization is the National Fire Association. Since its creation in 1896, the NFPA's standards and best practices has expanded the standardization of much that makes up the field of municipal fire protection. It is an international association devoted to reducing the impact of fire and related hazards and is comprised of over 50,000 members, most of which are located in the United States and Canada. Many members voluntarily on the 250 technical committees who oversee more than 300 standards or best practices guidelines including those that related to the design and performance of municipal fire apparatus.

The technical committees serve as the bodies responsible for developing and revising NFPA Standards. The committees review proposed changes to their assigned standard that are submitted either by a member of the committee or an interested party. Following a proposal solicitation period, technical committees review each proposal to determine if it has validity and be include in a future edition, warrant the creation of an additional standard or best practice. A proposal undergoes a review process that can consist of multiple layers of discussion and technical debate before being submitted for final approval.

Of the many NFPA standards, two serve as the primary reference for the specifications, design, performance and upkeep of motorized fire apparatus. The purpose and scope of these standards, NFPA 1901 and NFPA 1911, a described in some detail below:

NFPA 1901: Standard for Automotive Fire Apparatus.

Referenced throughout Canada and the United States by fire apparatus manufacturers, NFPA 1901 defines the requirements for new fire apparatus used to transport personnel and equipment for suppressing fires and other services provided by a fire department (National Fire Protection Association, 2016). The most current version of the standard was published in 2016. Electronic or paper copies of the standard can be obtained by contacting the NFPA.

Purpose. The purpose of the standard defines the minimum requirements for new fire apparatus designed to be used under emergency conditions to transport firefighters and equipment for fire suppression and other emergencies. The current edition was published in 2016 and as with all NFPA standards, normally undergoes a revision every 3-5 years.

Application. The standard applies to new fire apparatus that have 10,000 lb. (4,500 kg) or greater gross vehicle weight rating (GVWR) or are trailers intended to be towed by fire apparatus under emergency response conditions.

Background. The fire apparatus standard has its roots from initiatives from over one hundred years ago when in 1914 a collaboration between the National Fire Protection Association, the National Board of Fire Underwriters, and the International Association of Fire Engineers (fire chiefs) created the first edition of NFPA 19. In subsequent years the standard was revised with newer and more up to date editions. In 1975, the numerical designation of the document was changed to NFPA 1901 in a general renumbering of public fire protection standards, and the name was changed to *Standard on Automotive Fire Apparatus*. Since then, the standard has undergone extensive revisions with special emphasis placed on firefighter safety.

Currently, the standard is in the process of being consolidated into the publication of a new NFPA 1900 which when completed will be incorporate NFPA 1901 and that when published will also include the specifications for aircraft and wildland fire apparatus and ambulances. The specifications for these additional apparatus types currently reside in separate freestanding standards.

Scope. The standard addresses all aspects of fire apparatus specifications, performance and design. The standard is organized into several major chapters including administration, definitions, multiple chapters for each of the major apparatus types, detailed specifications of chassis, electrical system, pumps and other major components and annexes cover many supporting topics.

Apparatus Types. The standard organizes apparatus into eight different apparatus types. The different types depict the typical fire apparatus specified by most fire departments. The following provides a brief overview of the apparatus types found within the standard:

Pumper. A pumper, or engine as it is commonly referred to, is the most common of all fire apparatus types. The primary purpose of a pumper is to combat structural and associated fires, but also may be equipped to respond to other emergencies such as motor vehicle and hazardous material accidents. The primary features are a permanently mounted pump, a water tank, hose compartment and a limited number of ground ladders. The pump must have a minimum rated capacity of 3000 L/min (750 gpm). The water tank must be at least 1150 L (300 gallons) and has a minimum of 40 cubic feet (1.1 m^3) of compartment space is provided for nozzles, tools and minor equipment. A small complement of ground ladders is also included consisting of a straight ladder with roof hooks, an extension ladder, and a combination ladder that may be used on the interior of a structure. A minimum of two sections of hard intake hose is provided for drafting from static water sources. Pumper apparatus may also carry foam and proportioning system.

Initial Attack. Similar to a pumper, but on a smaller and lighter chassis, an initial attack apparatus, sometimes referred to as a mini-pumper, is equipped with a pump of at least 1000 Lpm (250 gpm) capacity, a water tank of at least 750 L (200 gal), and a hose body. The primary purpose of an initial attack apparatus is to initiate a fire suppression attack on structural, vehicular, or vegetation fire, and to support associated fire department operations. A minimum of 22 cubic feet (0.62 m^3) of compartment space is provided for various tools and equipment and

hose beds are designed to carry 2½ inch hose as well as a bed for storing 1 ½ inch (38 mm) pre-connected attack hose. Ground ladders include a minimum of a 12 ft. (3.7 m) or longer combination or extension type ladder. Pumper apparatus may carry foam and proportioning system.

Mobile Water Supply (Tanker). Sometimes referred to as a tender, this type of apparatus is designed primarily for support pumpers or other fire apparatus by transporting (pickup, transporting, and delivering) water to fire emergency scene. The apparatus is equipped with a pump, a water tank with a minimum capacity of 4000 L (1000 gallons) and at least 10 cubic feet (0.03 m^3) of compartment space for equipment storage. A hose bed is provided for the storing of 2 ½ inch (65 mm) or larger supply hose and 1 ½ inch (38 mm) attack hose. Tankers are not required to carry ground ladders. Suction lose and a portable pond are provided for drafting and water shuttle purposes.

Aerial Ladder Truck. An aerial ladder truck is a vehicle equipped with either an aerial ladder of at least 50 feet (15 m), elevating platform, or water tower device that is designed and equipped to support firefighting and rescue operations. The primary purpose is to provide access to upper floors or roof of a structure or discharging water at positions elevated from the ground. Some communities equip their aerial trucks with a pump and water tank and hose bed for added versatility. A minimum of 40 cubic feet (1.1 m^3) of compartment space is provided for storing of equipment. An assortment of straight and extension ground ladders totaling a minimum of 115 feet (35 m) must be provided.

Quint Apparatus. This apparatus is a combination of a pumper and aerial ladder truck. The pump must have a minimum rated capacity of 4000 Lpm (1000 gpm), an aerial device of a minimum of 50 feet (15 m), a water tank of at least 100 L (300 gallons) and 40 cubic feet (1.1. m^3) of compartment space for equipment. The apparatus must be able store a minimum of 30 cubic feet of 2 ½ inch (65 mm) hose and 3.5 cubic feet (0.1 m^3) of 1 ½ inch attack hose. A minimum of 85 feet (26 m) of assorted ground ladders must be carried.

Special Service Apparatus. A multipurpose vehicle that primarily provides support services at emergency scenes. These services could be rescue, command, hazardous material containment, air supply, electrical generation and floodlighting, or transportation of support equipment and personnel.

Mobile Foam Apparatus. Fire apparatus with a permanently mounted fire pump, foam proportioning system, and foam concentrate tank(s) whose primary purpose is the control and extinguishment of flammable and combustible liquid fire in storage tanks and spills.

Table 3.1 provides a cross reference of the minimum specifications of the major elements for each of the eight fire apparatus types.

Applying the Standard. The standard provides the design and specification criteria manufacturers of new fire apparatus. However, it is up to the purchasing fire department that choses which options within the criteria is met. As an example, the standard specifies an aerial device to be at 50 feet (15.25m) in length. The fire department developing the apparatus' specifications may

determine that based on the area where the apparatus will be assigned an aerial device for greater vertical and horizontal reach is warranted.

Very often a fire department has a preconceived idea of the type of new apparatus they wish to purchase. Often however, little consideration is given to the environment the apparatus will serve in. Purchasing a new fire apparatus is a significant investment by community. Every consideration should be given before specify highly technical, complex, and expensive fire apparatus. A detailed study should be made of the fire department's needs that considers the environment, climate, method of operation and existing apparatus.

The fire chief and supporting staff know best the conditions the apparatus will be used. However, it is encouraged to seek advice from knowledgeable sources such as members of the fire service that are knowledgeable about the specific fire apparatus being specified, professional magazines, maintenance staff, and fire apparatus manufacturers.

It would also be wise for the fire department to seek input from the Fire Underwriters Survey prior to beginning the specification process. This can ensure the apparatus will meet the fire insurance criteria that is specific the community being protected.
Annex B of NFPA 1901 provides a good overview of the specification procedure for new apparatus. Referencing the annex, the following excerpt provides an example of the many factors that should be considered when specifying a new apparatus:

- What are the typical emergency responses the apparatus will respond to (e.g., structure fires, wildfires, automobile accidents, medical assistance, rural water supply, special operations)?
- What is the response environment (e.g., rural and small villages with unpaved roads, bridges or roadways with weight limit or low clearance, older downtown districts with narrow streets and alleys, suburban neighborhoods, garden apartments, major expressways, etc.)?
- What is the maximum number of riding positions that will be needed?
- What size of pump is needed based on the response environment?
- How much and what sizes of hose are needed based on hydrant spacing and needed fire flows?
- Will the apparatus regularly respond to medical assist incidents? If so, what level of service will be provided e.g., first responder, medical technician, or paramedic)?
- What type of chassis will be used (e.g., commercial, or custom)?
- What type of chassis configuration (e.g., conventional, cabover, cab forward, or rear engine)?
- Are there any bay door size or floor weight limitations due to fire station or aprons?
- How much funding is budgeted for the purchase?
- What is the expected service life of the apparatus?
- What are other local or special considerations?

When beginning to specify a new apparatus, it is recommended a fire department review of the current edition of the standard. This is important a newer edition of the standard may have been issued since current apparatus in the fire department's fleet were purchased. While reviewing the standard it is important to review each section's corresponding material found within the annexes. The annexes provide explanatory information that can help clarify each section's technical requirements.

Table 3.1. NFPA 1901 Minimum Fire Apparatus Specifications by Type										
Apparatus Type	Pump	Tank	Intake Hose	Supply Hose Storage	Attack Hose Storage	Aerial	Tools & Equipment Storage	Ground Ladders	Foam	Usual # of riding Positions
Pumper (Engine)	Minimum rate capacity of 750 gpm (3000 L/min)	Minimum 300 gal. (1100 L)	20 ft (6 m) of suction hose/ 15 ft (4.5 m) of soft suction hose	Minimum 30 ft3 (0.8 m3) for 2½ in. (65 mm) or larger supply hose	Two areas: minimum of 3.5 ft3 (0.1 m3), to accommodate 1 ½ in. (38 mm	N/A	Minimum 40 ft3 (1.1 m³) of compart-mentation	Minimum of one straight ladder with roof hooks, an extension ladder, and a combination ladder	May be equipped with a foam proportioning system	4-6
Initial Attack (Mini-Pumper)	minimum rated capacity of 250 gpm (1000 L/min)	minimum 200 gal (750 L)	20 ft (6 m) of suction hose/ 15 ft (4.5 m) of soft suction hose	Minimum 10 ft3 (0.3 m3) for 2 ½ in. (65 mm) or larger supply hose	Two areas: minimum of 3.5 ft3 (0.1 m3), to accommodate 1 1 ⁄2 in. (38 mm)	N/A	Minimum of 22 ft3 (0.62 m3) of compart-mentation	A 12 ft (3.7 m) or longer combination or extension-type	May be equipped with a foam proportioning system	2-4
Mobile Water Supply (Tanker)	Not required unless specified by the purchaser	Minimum 1000 gal (4000 L)	With pump: 20 ft (6 m) of suction hose/ 15 ft (4.5 m) of soft suction hose	Minimum 6 ft3 (0.8 m3) for 21 ⁄2 in. (65 mm) or larger supply hose	If equipped with a pump, minimum of 100 ft (30 m) of 11⁄2 in. (38 mm) or larger attack hose	N/A	Minimum of 10 ft3 (0.0.3 m3) of compart-mentation	Not required unless specified by the purchaser	May be equipped with a foam proportioning system	2-4
Aerial (Ladder Truck)	Not required unless specified by the purchaser	Not required unless specified by the purchaser Optional	With pump: 20 ft (6 m) of suction hose/ 15 ft (4.5 m) of soft suction hose	May be provided, no specific size required	Two areas: minimum of 3.5 ft3 (0.1 m3), to accommodate 1 1 ⁄2 in. (38 mm)	May be aerial ladder, elevating platform, or water tower of at least 50 ft (15 m) in height	Minimum of 40 ft3 (1.1 m3) of compart-mentation	Minimum of 115 ft (35 m) of ground ladders	May be equipped with a foam proportioning system	4-6
Quint (Combination pumper & aerial Ladder Truck)	minimum rated capacity of 1000 gpm (4000 L/min)	Minimum 300 gal. (1100 L)	20 ft (6 m) of suction hose/ 15 ft (4.5 m) of soft suction hose	Minimum 30 ft3 (0.8 m3) for 21⁄2 in. (65 mm) or larger supply hose	Two areas: Minimum of 3.5 ft3 (0.1 m3)	Aerial device of at least 50 ft (15 m) in height	Minimum of 40 ft3 (1.1 m3) of compart-mentation	Minimum of 85 ft (26 m) of ground ladders	May be equipped with a foam proportioning system	4-6
Special Service Apparatus (Squad/Rescue, etc.)	Not required unless specified by the purchaser	Not specified	Not specified	Not specified	Not specified	Not specified	Minimum of 120 ft3 (3.4 m3) of enclosed compart-mentation	Not specified	Not specified	2+
Mobile Foam Apparatus	Minimum rated capacity of 750 gpm (3000 L/ min)	Minimum foam capacity of 500 gal (2000 L)	20 ft (6 m) of suction hose/ 15 ft (4.5 m) of soft suction hose	800 ft (240 m) of 21⁄2 in. (65 mm) or larger hose	400 ft (120 m) of 11⁄2 in. (38 mm), 13⁄4 in. (45 mm), or larger	May be aerial ladder, elevating platform, or water tower of at least 50 ft (15 m) in height	Minimum of 40 ft3 (1.13 m3) of enclosed compart-mentation	Not specified	May be equipped with a foam proportioning system	2+

NFPA 1911: Standard for the Inspection, Maintenance, Testing, and Retirement of In-Service Emergency Vehicles.

A companion standard to NFPA 1901, the NFPA's Standard 1911 was developed to assist fire departments in developing comprehensive programs for the inspection, maintenance, and testing of fire apparatus and included detailed guidelines for each program (National Fire Protection Association, 2017). The standard includes provisions for apparatus refurbishment and retirement.

Purpose. The primary purpose of this standard is to provide requirements for an inspection, maintenance, and testing program that will ensure that in-service emergency vehicles are serviced and maintained to keep them in safe operating condition and ready for response at all times. The standard emphasizes safety as a primary concern for the continued in-service use of an emergency vehicle and the ultimate decision to refurbish or retire that emergency vehicle.

Application. The standard is intended to apply, regardless year of manufacture, to public, governmental, military, and private organizations providing rescue, fire suppression, emergency medical services, hazardous materials mitigation, special operations, or other emergency services.

Background. The first edition of NFPA 1911 was issued in 1987 and was titled *Standard on Acceptance and Service Tests of Fire Department Pumping Apparatus*. It incorporated much of the material formerly included in the pamphlet *Fire Department Pumper Tests and Fire Stream Tables*, published by the National Board of Fire Underwriters and later by the Insurance Services Office. In 2007 two related standards, NFPA 1914, *Testing Fire Department Aerial Devices* and NFPA 1915, *Standard for Fire Apparatus Preventive Maintenance Program*, were consolidated into a new edition of NFPA 1901.

Scope. The standard defines the minimum requirements for establishing an inspection, maintenance, and testing program for in-service emergency vehicles. Provisions are also made for apparatus undergoing refurbishment and retirement. The standard identifies the systems and items on an emergency vehicle that are to be inspected and maintained, the frequency of such inspections and maintenance, and the requirements and procedures for conducting performance tests on components.

Overview. The standard is applicable to both public and private fire apparatus and provides guidance for safe and reliable operation and includes the minimum requirements for their inspection, maintenance, and testing programs. The following provides an overview of the standard:

1. *Administration*
   - The scope of work determines the requirements for establishing an inspection, maintenance and testing for in-service fire apparatus
   - Criteria for fire-apparatus refurbishment and retirement
   - Defines the applicability of standard on public and private organizations for using fire apparatus

2. *Referenced Publications*
    - Referral to sections within other NFPA standards
- Related documents published by other organizations or government entities

3. *Definitions*
    - Included are NFPA official terms and general definitions

4. *General Requirements*
- Requirements for in service apparatus inspection, maintenance, testing and retirement
- Qualifications and safety of maintenance personnel
- Inspection and maintenance procedures.
- Records

5. *Apparatus Retirement*
- Retirement process
- Use of retired apparatus

NOTE: Fire Underwriters Survey has published the document Insurance Grading Recognition of Used and Rebuilt Fire Apparatus. In summary:

- Apparatus is built to applicable ULC S515 or NFPA 1901 standards.
- Apparatus should respond to first alarms for the first 15 years. For the next 5 years, be in reserve status for use at major fires or as a temporary replacement for out-of-service first line apparatus.
- Be retired at 20 years of age, unless the apparatus meets the recommended annual, service and acceptance level tests and has been deemed in excellent mechanical condition
- Testing includes, weight, road and pump performance tests.
- Testing and maintenance only be completed by a qualified technician.

A more detailed overview of the FUS apparatus recognition criteria can be found in Section V of this report.

6. *Out-of-Service Criteria*
- Apparatus deficiencies
- Apparatus retesting

7. *Daily/Weekly Visual and Operational Checks*
    - Minimum requirements for apparatus operational checks
    - Maintenance procedures
    - Records

8. *Inspection and Maintenance of the Chassis, Driving and Crew Compartment, and Body*
    - Inspection and maintenance of chassis, driving, crew compartment, and body components and systems

- Inspection of axles, tires and wheels, engine fuel systems, engine cooling systems, steering systems, braking systems, transmission compartments and systems.
- Documentation of operational checks, tests, out-of-service, repairs and maintenance

9. *Inspection and Maintenance of Low-Voltage Electrical Systems*
   - Inspection and maintenance of low voltage electrical equipment on the apparatus

10. *Inspection and Maintenance of Water Pumping Systems and Water Tanks*
    - Inspection and maintenance of water pumps, water tanks, auxiliary pumps, industrial pumps, transfer pumps and priming system

11. *Inspection and Maintenance of Aerial Devices*
    - Inspection and testing of aerial devices
    - Hydrostatic inspection of aerial devices equipped with air storage

12. *Inspection and Maintenance of Foam Proportioning Systems*
    - Inspection and maintenance of foam proportioning systems including cleaning of systems components, instrumentation and controls for security checks

13. *Inspection and Maintenance of Compressed Air-Force Systems (CAFS)*
    - Inspection and maintenance of compressed air-foam systems equipped with either air-compressors or power takeoff-driven compressors

14. *Inspection and Maintenance of Line Voltage Electrical Systems*
    - Inspection and maintenance of line voltage electrical system including appliances and circuit breakers
    - Inspection of engine-driven generators for condition, diagnostic, leaks, deformation and security of mounting

15. *Inspection and Maintenance of Utility Air and Breathing Air Systems*
    - Inspection and maintenance of compressed breathing air systems or utility air
    - Inspection and maintenance of system components such as piping, air compressors, purification systems, and air storage tanks must the checked for leaks, deformation, security of mounting
    - Records

16. *Inspection and Maintenance of Trailers*
    - Inspection and maintenance of trailers including system components such as frame, hitch, axle, suspension, brakes systems, and electrical and lighting
    - Records

17. *Inspection and Maintenance of Patient Compartment*
    - Inspection and maintenance of patient compartment including doors, locks and latches, seatbelts, HVAC, fire extinguishers, and handrails and mounts
    - Records

18. *Inspection and Maintenance of Winch Systems*
    - Inspection and maintenance of winches including cleaning of assembly, unwinding wires and checking power and supply controls for wear, cracking, and abrasion

19. *Road Tests and Annual Weight Verification*
    - Testing chassis components, braking systems and parking brake systems
    - Road testing

20. *Performance Testing of Low-Voltage Electrical Systems*
    - Testing of major components including batteries, load testing, starter wiring, alternator, regulator, and battery charger

21. *Performance Testing of Fire Pumps and Industrial Supply Pumps*
    - Inspection and maintenance of fire pumps and supply pumps
    - Test site
    - Environmental conditions

22. *Performance Testing of Aerial Devices*
    - Inspection and testing of aerial devices including welds, bolts and pins, aerial ladders, rotation gear and bearing

23. *Performance Testing of Foam Proportioning System*
    - Inspection and testing of foam proportioning systems

24: *Performance Testing of Compressed Air Foam Systems (CAFS)*
    - Inspection and testing of compressed air foam systems

25. *Performance Testing of Line Voltage Electrical Systems*
    - Inspection and testing of line voltage electrical systems

26. *Performance Testing of Breathing Air Compressor Systems*
    - Testing of breathing air compressor system including air quality

UL-Canada Standard S515: Standard for Automobile Firefighting Apparatus.

The UL Standard S515 (Underwriters Laboratories Canada, 2013) is similar to NFPA Standards though there are small but important differences. The Standard is important in that manufacturers are accustomed to meeting this standard, and may be reluctant to deviate for reasons of liability or deviation from established practice. Compliance is essentially a *de fac*to requirement, even if not required under law (Adams, 2018).

Scope. The standard defines the minimum performance requirements for new automobile firefighting apparatus such as pumpers, water tank trucks, ladder trucks, aerial devices and combinations of these, as used for structural firefighting in the municipal fire service.

The standard describes the minimum requirements for the most common types of apparatus and the requirements for each of their components. The standard does not cover optional equipment

typically carried by the various types of firefighting apparatus and the variety of combinations and functions of this equipment.

The standard includes general requirements with the remainder of the contents organized into the following sections:

Part I, Apparatus Requirements. Included are design and specification requirements common fire apparatus types including pumpers, aerial ladder trucks, initial attack (mini-pumpers), quints, mobile foam, mobile water, and special services vehicles.

Part II, Equipment Requirements. Included are criteria for chassis, engine and apparatus components, low-voltage electrical systems and warning devices, driving and crew areas, body compartments and equipment mounting, fire pumps and water tanks, aerial devices, foam systems, compressed air foam systems, line voltage electrical systems, command and communications, air systems, winches and trailers.

Included are appendices for limiting design stresses and recommended practices for apparatus maintenance, inspection, and testing of in-service apparatus.

The FUS and Used or Rebuilt Fire Apparatus

Supplementing the criteria within NFPA 1901 and 1911 and Standard S515, the FUS has developed a standard for acceptance of apparatus as the apparatus becomes less reliable with age and use (Fire Underwriters Survey). Unlike passenger and commercial vehicles, fire apparatus are unique in that they are not continuously in use, but when pressed into service they are subject to considerable mechanical stress due to the extremes of firefighting operations.

This ongoing stress may not be detected from the exterior of the apparatus and is often masked by the fire services high level to aesthetics. As the apparatus ages, this stress, along with replacement parts presents many challenges for the fire department whose desire is to have in service first-rate equipment. A Lack of replacement parts are at a premium as manufacturers maintain fewer and fewer a parts inventory as apparatus ages. The department's ability to maintain the fleet becomes challenging as parts and servicing becomes difficult, particularly in the narrow and specialized market such as fire apparatus.

The FUS credits fire apparatus that are designed per the specifications of a recognized standard. As discussed, the standards recognized by the FUS is the Underwriters' Laboratories of Canada (ULC) Standard S515 (most updated version) titled, "Automobile Fire Fighting Apparatus," which was adopted as a National Standard of Canada. Alternatively, NFPA 1901, the Standard for Automotive Fire Apparatus is also accepted by FUS with respect to apparatus design. Fire apparatus should be built by recognized manufacturers and tested by a suitably accredited third party.

A frontline apparatus is recognized by the FUS for the first fifteen years of service that demonstrate a performance without failure for at last 95 percent of the time. Fire next five years the apparatus should be place in reserve status where it may be used while frontline apparatus is

out of service or during major events such as conflagrations, other large-scale emergencies or similar incidents.

The FUS recommends apparatus to be retired from service after 20 years of service. Their research has shown this most often is the practice by the original purchasing fire department. However, upon the retirement of the apparatus it is often sold to another department, sometimes in less than desirable condition. Under these conditions, the apparatus is often found to have many performance and maintenance issues that could impede its performance during firefighting operations. Examples of common deficiencies include:

- Worn and unsafe braking system
- Weak acceleration
- Weakened chassis due to overloading
- Excessive wear on pump and piping
- Rust and deteriorating bodywork and compartments
- Substandard design

Due to many communities, especially in the rural area, having limited funds for the purchase of new fire apparatus, the FUS under certain conditions recognize apparatus over 20 years of age provided the apparatus successfully meets the recommended annual tests as set forth in NFPA 1911 and is in excellent mechanical condition. The recognized service life and test frequencies criteria recognized by the FUS to determine the condition of older apparatus is defined in Tables 3.2 and 3.3. Testing and apparatus maintenance work should be performed by a certified technician that is certified to an appropriate level of certification per NFPA 1071, *Standard for Emergency Vehicle Technician Professional Qualifications*.

Table 3.2 – Service Schedule for Fire Apparatus for Fire Insurance Grading Purposes

Apparatus Age (years)	Major Cities [3]	Medium Sized Cities [4]	Small Communities and Rural Centres [5]
0-15	First Line Duty	First Line Duty	First Line Duty
16-20	Reserve	2nd Line Duty	First Line Duty
20-25 [1]	No Credit in Grading	No Credit in Grading, *or* Reserve [2]	No Credit in Grading, *or* 2nd Line Duty [2]
26-29 [1]	No Credit in Grading	No Credit in Grading, *or* Reserve [2]	No Credit in Grading, *or* Reserve [2]
30+	No Credit in Grading	No Credit in Grading	No Credit in Grading

[1] All listed fire apparatus 20 years of age and older are required to be service tested by recognized testing agency on an annual basis to be eligible for grading recognition. (NFPA 1071) on an annual basis to be eligible for grading recognition. (NFPA 1071)

[2] Exceptions to age status may be considered in a small to medium sized communities and rural centres conditionally, when apparatus condition is acceptable and apparatus successfully passes required testing.

[3] Major Cities are defined as an incorporated or unincorporated community that has: • a populated area (or multiple areas) with a density of at least 400 people per square kilometer; AND • a total population of 100,000 or greater.

[4] Medium Communities are defined as an incorporated or unincorporated community that has: • a populated area (or multiple areas) with a density of at least 200 people per square kilometer; AND/OR • a total population of 1,000 or greater.

[5] Small Communities are defined as an incorporated or unincorporated community that has: • no populated areas with densities that exceed 200 people per square kilometer; AND • does not have a total population in excess of 1,000.

Table 3.3 - Frequency of Listed Fire Apparatus Acceptance and Service Tests

	Test Frequency					
	@ Time of Purchase New or Used Annual Basis	Annual Basis	@ 15 Year	@ 20 Years *See Note 4*	20 to 25 Years (annually)	After Extensive Repairs *See Note 5*
Recommended For Fire Insurance Purposes	Acceptance Test if new; Service Test if used & < 20 Years	Service Test	Acceptance Test	Acceptance Test	Acceptance Test	Acceptance or Service Test depending on extent of repair
Required For Fire Insurance Purposes	Acceptance Test if new; Service Test if used & < 20 Years	No Test Required	No Test Required	Acceptance Test	Acceptance Test	or Service Test depending on extent of repair
Factor in FUS Grading	Yes	Yes	Yes	Yes	Yes	Yes
Required By Listing Agency	Acceptance Test	No	No	No	N/A	Acceptance Test
Required By NFPA See Note 6	Acceptance Test	Annual Service Test	Annual Service Test	Annual Service Test	Annual Service Test	Service Test

Note 1: See: '*Service Tests for Used or Rebuilt Fire Apparatus*' for description of applicable tests
Note 2: Acceptance Tests consist of 60-minute capacity and 30-minute pressure tests
Note 3: Service Tests consist of 20-minute capacity test and 10-minute pressure test in addition to other listed tests
Note 4: Apparatus exceeding 20 years of age may not be considered to be eligible for insurance grading purposes regardless of testing. Application must be made in writing to Fire Underwriters Survey for an extension of the grade-able life of the apparatus.
Note 5: Testing after extensive repairs should occur regardless of apparatus age within reason.
Note 6: Acceptance Tests: See NFPA 1901, *Standard for Automotive Fire Apparatus Service Tests*: See NFPA 1911, *Standard for Service Tests of Fire Pump Systems on Fire Apparatus*, Article 5.1

Recognition of a used or rebuilt apparatus may be extended for a limited period of time if documentation verifying the apparatus has successfully passed the specified tests. If the apparatus does not pass the required tests or experiences long periods of "downtime" the fire department may be required to replace it new or newer apparatus. If replacement does not occur, the apparatus may be considered "unrecognized" which in turn may adversely affect the fire insurance grades of the community.

For an expanded overview of the above criteria refer to Section V and the FUS Technical Bulletin, *Insurance Grading Recognition of Used or Rebuilt Fire Apparatus.*

The FUS Apparatus Acceptance Terms of Reference for Fire Insurance Grading and Public Fire Protection Classification

The FUS evaluates the ability of the fire department to provided required fire flows through the assessment of its apparatus.

- If recognized apparatus can receive full credit if it is of an appropriate age and is ULC listed[1].
- If apparatus is designed to meet all of the requirements of NFPA 1901, and has been tested and evaluated for its compliance with NFPA 1901, by an accredited agency[2], then it can also receive full credit.

- If the apparatus does not meet one of the two above criteria, then some credit between 0-100% would be applied to the apparatus within the calculation of fire insurance grades.
  - This credit is based on an analysis of the reliability of the apparatus with respect to its capacity of continuously provide emergency response and all related intended purposes (as specified in ULC S515 and/or NFPA 1901):
    - Apparatus design standard and specifications;
    - Age of apparatus;
    - Results of apparatus acceptance and service testing (including, but not limited to, weight, road and pump performance tests);
    - Accident history;
    - Out of service history;
    - Frequency of testing and indications of apparatus reliability; and
    - Frequency of maintenance and indications of apparatus reliability.

[1] Listed by ULC means that the apparatus has been tested and certified through "listing" and a ULC plate (indicating listing number) has been applied to the apparatus. The testing and certifying organization must be a Standards Council of Canada accredited agency (ULC is an accredited agency). Listing of the apparatus implies the apparatus meets all of the requirements of the standard ULC S-515.

[2] NFPA 1901, Standard for Automotive Fire Apparatus, lists requirements for third party certification under section 4.7

IV: New Technologies

There are several new technologies that represent viable alternatives to the traditional triple combination pumper or engine apparatus. These technologies have accumulated varying degrees of experience, but all have been validated in multiple settings. The advantages of these technologies center on lower cost, ability to use smaller, lighter apparatus, and more efficient use of water or novel extinguishing agents to reduce the need for large water tanks or connection to an external water supply.

Although they are regarded as "new" technologies, the fundamental concepts date back many years. The use of fog and alternative fire attack methods dates back to Worl War II and research by the US Navy (Norwood & Salameh, 2020). High pressure fog was used as an extinguishing agent and first marketed commercially in the 1940s (Pulver, 1943).

Similarly, compressed air foam was developed by military, and it was decades before it was resurrected by a US-based manufacturer. The compressed air foam systems were first used in wildland settings, where restricted water supplies were common. They later came into use for structural firefighting.

The mini-pumper (use of a lightweight chassis for a firefighting vehicle with smaller pump, tank, and reduced equipment, is attributed to Syracuse, New York dating to the early 1970s (Syracuse Mini-Pumper History, 2006).

Tying these concepts together has resulted in several innovative and tested technologies for firefighting. The new technologies can be considered in several primary categories defined by both the extinguishing technology and the vehicle used to deliver the agent to the scene of the emergency. They offer promise for consideration for high-challenge Indigenous communities.

Apparatus Form Factor

The common thread among these new technologies is their deployment on a smaller, lightweight vehicle. While they can be installed and used on full-size apparatus, their usage on lightweight vehicles is recognized as the frontier for use in situations where staffing or water supplies are limited. These concepts are not necessarily recognized by the Fire Underwriter's Survey, but nonetheless could provide useful alternatives to increase the level of fire protection.

Mini Pumper

Mini Pumpers may be a worthwhile firefighting vehicle for some Indigenous Communities. The 2019 Inventory of Indigenous Community's firefighting assets show mini pumpers are in service in all the Provinces.

Mini Pumper Definition -- A fire apparatus built on a commercial light truck cab & chassis, often equipped with a 500 gpm US (1900 L) fire pump, water tank capacity of no more than 300 US gal (1150 L), limited storage compartment capacity, a smaller number of hoses, nozzles, fittings, and equipment than a triple combination engine, yet congruent to it.

Mini-pumpers are used in diverse locales, including demanding fire and climate environments (Cromer, 2001; Petrillo, 2017).

Fire response for those Indigenous Communities who are unable to afford the cost of a triple combination pumper. In larger Indigenous Communities where Triple Combination Engine Road travel distance is in excess of eight kilometers, strategic placement of multiple Mini Pumper stations could result in more prompt fire department arrival times and more rapid-fire control or at least knockdown until the later arrival of the triple combination engine or tanker.

More recently, Mini Pumpers may have fire pumps with larger capacities up to 1250 gpm (5000 L) US rating. A rapid response and quick attack fire knockdown may extinguish many early detected fires. For fires not extinguished with Mini Pumper tank water, establishing a supply line from an arriving tanker or engine will expedite recommenced firefighting operations, as the attack lines are already stretched, in place, and staffed. The supply of tank water should be sufficient to either extinguish a single room within a dwelling. If the original structure was fully involved, the fire extinguishing capacity should be sufficient to prevent fire spread to the adjoining exposures.

The training requirements for driving the Mini Pumper and operating it at incidents is significantly less than that required for a triple combination pumper. In Indigenous Communities where the firefighting force is primarily volunteer, this may be beneficial. In the worst-case scenario, one firefighter can operate the Mini Pumper and commence exterior firefighting operations. A second firefighter arriving with the Mini Pumper results in a much more effective and efficient commencing of fire suppression. If the firefighters are certified to operate in Self Contained Breathing Apparatus, SCBA, then an aggressive interior search and fire suppression operation can occur.

If the firefighters are not SCBA certified, then an exterior attack, either through a window or via a wall penetrating nozzle can commence. Recent studies on controlling the flow path of fire gases have found that the through the wall fire attack method is more effective in controlling the fire than breaking the window to attack the fire. In addition to making an entry point for the nozzle, breaking the window also create a path for air to enter the fire space, potentially causing oxygen-controlled fires to grow in intensity,

As the Mini Pumper is built on a light truck cab & chassis, preventive maintenance, replacement costs and repair costs should be lower due to the greater availability of parts and more locally located authorized repair facilities.

Fire Hall building requirements to safely house the Mini Pumper should also be less expensive to construct and maintain than those housing a triple combination engine.

Rapid Response Vehicles

A subset or closely related vehicle is the rapid response vehicle. While the definition can be considered closely related to that of the Mini-Pumper, these units are distinguished by their emphasis on small size, as well the use of novel or non-traditional firefighting technologies.

A Rapid Response Vehicle, RRV, is a vehicle built on a light duty truck cab & chassis that relative to a full-size triple combination engine:

- Has lower initial purchase cost
- Has lower ongoing maintenance & operation costs
- Requires smaller fire hall vehicle storage space
- Is much lighter in weight
- Has smaller overall dimensions
- Has better handling characteristics
- Has greater maneuverability
- Quicker Travel Time due to its maneuverability and decreased weight
- Carries less tank water
- Generally, an all-wheel drive, AWD, or four-wheel drive vehicle
- Can go off-road
- Has shorter qualified operator training period
- Has firefighting capability to extinguish incipient fires
- Can knock down or slow the progress of free burning fires until the arrival of additional firefighting resources

DeKalb County Georgia (US) is a pioneer in the development and utilization of the Rapid Response Vehicle concept. They utilize a 30-(US) gallon CAFS system with hose reel (Video: DeKalb County (GA) Fire Rescue Department Rapid Response Vehicle, 2019). DeKalb has deployed multiple units, beginning in 2019 (DeKalb County, 2019).

They expanded their fleet to add 10 more units. Since the inception of the RRV program responses by the full-size fire vehicles has decreased to under three thousand runs for the busiest of companies. Benefits include longer vehicle life expectancy, units in service in district for fire response, lower incident of adjoining companies responding to a neighboring station's district because units are unavailable, reduced fleet maintenance costs, greater periods of time between scheduled Preventive Maintenance due to lowered use. Demand on full-size apparatus decreased by 14 percent, and response times improved by 26 percent (Government Fleet Staff, 2019).

Tracked Vehicles

Tracked vehicles with firefighting capability may be a desirable option for some Indigenous communities. Locations without paved roads, those with heavy winter snow and ice conditions, and those locations where the warmer weather results in thawing of the ground and boggy conditions are examples of where track firefighting vehicle may be preferable to wheeled drive vehicles.

There are a variety of options to outfitting a track vehicle for firefighting. Manufacturers offer varying size and payload capacities. Some manufacturers supply the fire fighting equipment in addition to the track vehicle. Others supply just the track vehicle, and the customer outfits the vehicle with the firefighting component such as a skid unit. The skid units can be standard water firefighting capability, Compressed Air Foam Systems (CAFS), or Ultra High Pressure (UHP)

capability. A list of manufacturers is included in the Appendices.

Novel Extinguishing Technologies

The Mini-Pumper or Rapid Response Vehicle can be configured as a standard water only unit, or use novel technologies. Aside from the choice of a lightweight vehicle to transport and deliver the extinguishing agent, there are two technologies in use that may be of interest. We will discuss each of these technologies and their advantages and any drawbacks or concerns.

Either of the technologies can be provided integrally mounted with he vehicle, or can be provided in what is known as a "skid-mount" unit that is designed to slip into a pickup truck bed or be bolted onto a vehicle compartment. A skid-mount is a self-contained unit combining fire pump, engine to power pump, water tank and hose lines, packaged as a unit, sized to fit into the bed of pickup trucks or on a flatbed stake truck. Generally, a forklift is utilized to place the skid mount unit on and off the vehicle. Smaller skid mount units are also made to fit on All Terrain Vehicle, ATV, platforms.

A skid mount pump unit, pickup truck slide in or ATV mounted, may be an asset for smaller Indigenous communities where accessibility, cost, and terrain are issues. Adequate storage costs are less expensive. Operator Qualification Training requirements are significantly less than that of a triple combination engine operator.

Skid Mount units can function as a stand-alone firefighting unit in smaller, remote Indigenous communities where currently there may be very little or no firefighting capability. The off-road capability of the Skid Mount unit will allow it to gain access to brush or wildland fire to extinguish the fire before the fire can spread and threaten the community.

Compressed Air Foam Systems (CAFS)

In a Compressed Air Foam System, (CAFS), an engine, an air compressor and piping from the compressor to the CAFS discharge valves is installed. This will the increase the initial cost of a CAFS engine more than a standard engine. Whie foam was originally used to extinguish flammable or combustible liquids fires, it has come into usage for Class A fires.

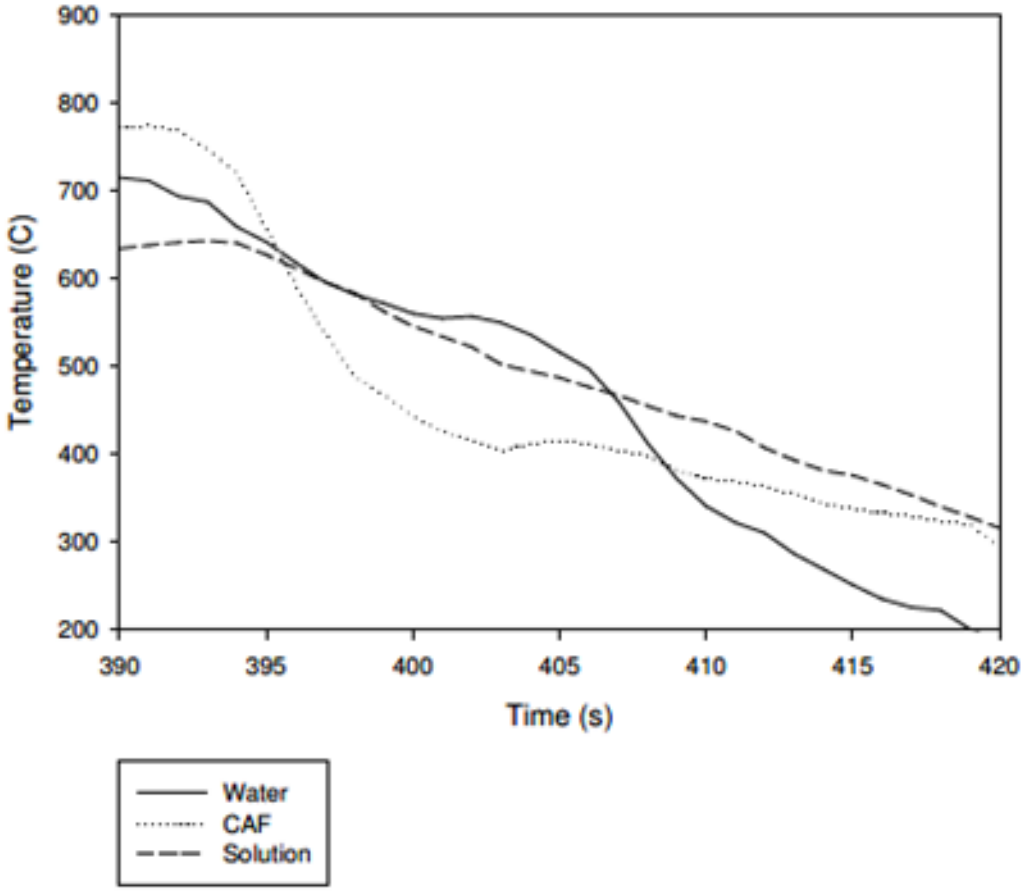
There are multiple studies evaluating the effectiveness of CAFS versus traditional water as a structural fire extinguishing agent. While some were inconclusive (Mitchell, 2013), the overall research is supportive of the effectiveness of CFAS as a structural fire suppression tool, but its effectiveness may be comparable to water.[1]

The National Research Council of Canada performed an evaluation of alternative fire suppression systems, to include CAFS, in 2012. They conducted a series of fire tests on a 38 m^2 room provided with standardized furnishings. They found that "the CAF system is more effective in suppressing a compartment fire than hose stream with water only" (Kim & Crampton, 2012).

[1] Of course, in a water-deprived environment, CAFS may have additional advantages of necessity.

Figure 4.1 shows the comparison of reduction of room temperature over time using water, UHP, and CAFS.

Figure 4.1: Time versus Temperature and Extinguishing Agent



Source: NRCC-55249 Fire Suppression of Manually Applied CAF and Other Water Based Systems

A later study conducted by the National Institute of Standards and Technology used multiple scenarios in a structure with mixed combustibles to find that "both the gas cooling and the suppression of residential scale room fires showed the effectiveness of water and CAFS to be similar." The study did not evaluate CFAS for exposure protection or prevention of rekindle (Weinschenk, Madrzykowski, Stakes, & Willi, 2017, p. 62).

Disadvantages of CAFS include a grater nozzle reaction force, environmental impacts of foam runoff, less resistance of hoselines to burn-through than standard water, and hoseline handling characteristics in the event of a system malfunction (Mitchell, 2013, pp. 13-14). The systems also are more complex, and require regular maintenance.

Ultra-High Pressure Firefighting Unit (UHP)

Ultra-High Pressure, UHP, Firefighting may be defined as any firefighting with a nozzle pressure discharge in excess of 1100psi (Figure 4.1). A number of studies have been conducted of this technology, which grew from US Air Force utilization and adoption.

Table 4.1: Classification of Pump Pressures

PSI at the Pump	
0-300	Low pressure
300-800	Medium pressure
800-1000	High pressure
1100 and up	**Ultra-high pressure**

Source: (MDM Publishing, 2014).

US Air Force studies of UHP firefighting found that nozzle pressure of 1100psi resulted in the optimum water droplet size for maximum heat of fire combustion absorption. Although the studies were conducted in support of aircraft rescue firefighting, ARFF (Grosskopf & Kalberer, 2008), the fire suppression concepts hold true for structural firefighting as well.

In another study, researchers endorsed the use of UHP for structural firefighting of single-room fires at flashover. Reduced water damage was observed, and UHP could be delivered at a lower flow rate than would typically be required for a low-pressure hose stream (McDonald, 2017).

UHP Water usage between the two technologies was similar. Because of high pressure discharge and low flow rates, fire can be extinguished with less total gallons, resulting in the ability to reduce water tank size and overall vehicle weight.

The lesser amount of water required for extinguishment via UHP firefighting is significant to note. For Indigenous communities with no municipal water system fire extinguishment via tank water negates the need to shuttle water from remote static sources. In freezing weather operations when the static source may be covered by a thick layer of ice this is a significant advantage.

For structural firefighting, the UHP set up can be purchased as a pump on a new apparatus, a retrofit add on pump to an existing apparatus or a self-contained skid mount pump unit. The use of UHP in structural firefighting is gaining ground. The use of UHP was recognized by the International City/County Management Association's annual awards program. The City of

Bondourant, Iowa has deployed two UHP rapid intervention vehicles by adding the capability to existing a brush truck and command vehicle. One of the vehicles UHP unit is equipped with a heater and is used as a take-home vehicle, enabling immediate response direct to the scene. The City reports faster response times, faster fire suppression, reduced water damage, and reduced war-and-tear which has extended the lifespan of traditional heavy apparatus. (International City/County Management Association, 2021)

The combined light weight load of both pump and water supply tank makes the UHP unit an attractive rapid response vehicle. The initial cost is much less than that of a triple combination pumper. Driver and operator training time is much less than that required for a triple combination engine operator.

The rapid response capability, training requirements, and ability for exterior fire attack may make this a good purchase option for Indigenous communities where staffing and training are issues.

V: Apparatus Policy Program

This section will address those topics that must be included in a comprehensive apparatus policy program. Such a program must encompass not only specification and acquisition of new apparatus, but the maintenance of existing apparatus, and criteria for replacement, refurbishment, or repurposing. We will consider these decisions in light of existing community conditions, demands for service, and industry practice, including Fire Underwriter's standards.

Methodology for Assessing Current Apparatus Condition.

It is generally understood that the lifespan of fire apparatus is affected largely by its utilization, local environment, operating conditions, and the level and frequency of preventive maintenance. As an example, the lifespan of a pumper subjected to moderate and heavy use may be estimated at 10 to 15 years, whereas an aerial ladder truck subjected to light to moderate use is estimated at 15 to 20 years. In contrast, the life span of fire apparatus subjected to very light use may be estimated at 20 or more years.

When a first-line apparatus has reached its lifespan, it may be placed in reserve status for a reasonable time period, provided it remains in good operating condition and undergoes regular preventive maintenance. NFPA 1901 recommends an apparatus should be removed from service after 25 years. For a fire department to optimize an apparatus, a program should be in place to ensure its serviceability and dependability.

FUS As mentioned in Section III, the Fire Underwriters Services has in place testing criteria for used or modified apparatus that are older than 20 years of age. The intent of the criteria is to ensure that all used or modified fire apparatus, equipped with a pump or used for tanker service, essentially meet the requirements of Underwriters' Laboratories of Canada (ULC) "Standard for Automobile Fire Fighting Apparatus" S515-04 or subsequent (current) editions of the Standard. To be recognized, apparatus must be in complete adherence with the following specified tests.

Table 5.1 – FUS Service Tests for Used or Modified Fire Apparatus

Weight Tests	
Load Balance Test:	When fully laden (including a 460kg (1000 lbs.) personnel weight, full fuel and water tanks, specified load of hose and miscellaneous equipment), the vehicle shall have a load balance of 22% to 50% of total vehicle mass on the front axle and 50% to 78% of this mass on the rear axle. Distribution of mass of 33% and 67% respectively on the front and rear axles is preferable for a vehicle having dual rear tires or tandem rear axles. For a vehicle having tandem rear axles and dual tires on each axle, a loading of between 18% and 25% on the front axle with the balance of mass on the rear axles is permissible.
Road Tests	
Acceleration Tests:	From a standing start, the apparatus shall attain a true speed of 55 km/h (35 mph) within 25 seconds for Pumpers carrying up to 3,150 litres (700 gallons) of water. For apparatus carrying in excess of 3,150 litres (700 gallons) or apparatus equipped with aerial ladders or elevating platforms, a true speed of 55 km/h (35 mph) in 30 seconds should be attained. The vehicle should attain a top speed of at least 80 km/h (50mph).
Braking Test:	The service brakes shall be capable of bringing the fully laden apparatus to a complete stop from an initial speed of 30 km/h (20 mph) in a distance not exceeding 9 metres (30 feet) by actual measurement. The test should be conducted on a dry, hard surfaced road that is free of loose material, oil and grease.
Pump Performance Tests	
Hydrostatic Test	Recent evidence of hydrostatic testing of the pump for 10 minutes at a minimum pressure of 3,400 kPa (500 psi). APPLICABLE TO NEW OR REBUILT PUMPS ONLY
Priming and Suction Capability Tests	Vacuum Test: The pump priming device, with a capped suction at least 6 metres (20 feet) long, shall develop –75 kPa (22 inches of mercury) at altitudes up to 300 metres (1000 feet) and hold the vacuum with a drop of not in excess of 34 kPa (10 inches of mercury) in 10 minutes. For every 300 metres (1000 feet) of elevation, the required vacuum shall be reduced 3.4 kPa (1 inch mercury). The primer shall not be used after the 10-minute test period has been started. The test shall be made with discharge outlets uncapped. Suction Capability Test: The pump (in parallel or series) when dry, shall be capable of taking suction and discharging water with a lift of not more than 3 metres (10 feet) through 6 metres (20 feet) of suction hose of appropriate size, in not more than 30 seconds and not over 45 seconds for 6000 L/min (1500 gpm (US)) or larger capacity pumps. Where front or rear suction is provided on midship pumps, an additional 10 seconds priming time will be allowed. The test shall be conducted with all discharge caps removed.
Pump Performance	
	Capacity Test: Consists of drafting water (preferably with 10 foot lift) and pumping the rated capacity at 1000 kPa (150 psi) net pump pressure for a continuous period of at least 1 hour. Pressure Test: Under the same conditions as in 3.3.1 above pumping 50% of the rated capacity at 1700 kPa (250 psi) net pump pressure for at least ½ hour.

Replacement

Fire departments should take special care when determining the cost of refurbishing an apparatus versus replacing it with a new one. A cost–benefit analysis of refurbishing an apparatus should be conducted. A good source for refurbishing guidelines is NFPA 1912. In some cases, fire departments have found that refurbishing costs can will greatly exceed the current value of similar apparatus. NFPA 1901 and 1911 provides the following factors when determining whether to refurbish or replace an apparatus:

1. What is the condition of the current apparatus? Has it been in a major accident, or has something else happened to it that would make spending significant money in it ill advised?

2. What advancements in design, safety, and technology have improved the efficiency and safety of personnel?

3. Does the current apparatus meet the program needs of the area it is serving? Is it designed for the way the fire department operates today and is expected to operate in the foreseeable future, or is the apparatus functionally obsolete? Can it carry everything that is needed to do the job without being overloaded?

4. If the apparatus is refurbished, will it provide the level of safety and operational capability of a new fire apparatus? It should be kept in mind that in many cases, refurbishing does not mean increasing the GVWR, so it is not possible to add a larger water tank or additional foam agent tanks or to carry massive amounts of additional equipment. Enclosing personnel riding areas might add enough weight to the chassis that existing equipment loads need to be reduced to avoid overloading the chassis.

5. What is the anticipated cost per year to operate the apparatus if it were refurbished? What would the cost per year be for a new apparatus? Insurance costs, downtime costs, maintenance costs, depreciation, reliability, and the safety of the users and the public all have to be considered. At what rate are those costs rising each year? Are parts still readily available for all the components on the apparatus? A refurbished 15-year-old apparatus still has 15-year-old parts in it. How long could the fire department operate without the apparatus if it suddenly needed major repairs?

6. Is there a current trade-in value that will be gone tomorrow?

Evaluating Apparatus. As with all vehicles, a fire apparatus has a finite life. The life span is impacted by many factors including mileage and engine hours, quality and frequency of preventative maintenance and repair, quality of the driver training program, use of the apparatus within its design parameters, whether the apparatus was manufactured on a custom or commercial chassis, quality of workmanship by the manufacturer, and availability of replacement parts.

In larger or busy fire departments, there are apparatus with 8 to 10 years of service that are nearing their service life. There is also apparatus that were designed and manufactured to a

higher standard, receive frequent and proper maintenance, that respond to a minimum number of incidents that are still in serviceable condition after 20 years. It is generally understood that the care of fire apparatus while in-service and a proactive and creditable maintenance program are the primary factors in determining how well an apparatus will age.

In addition, enhancements in design, functionality, and technology should be considered in the evaluation of an apparatus life cycle. Apparatus standards include many criteria for the advancement apparatus safety and user friendliness. Examples include rollover stability; tire pressure indicators; seat belt warning systems requiring all occupants be properly seated and belted; extended seat belt length requirements resulting from an in-depth anthropometric study evaluating the average size of today's fully dressed firefighter; roadability, including minimum accelerations and top speed limitations; enhanced step and work surface lighting; cab integrity testing; increased use of retroreflective striping in the rear of apparatus, providing a consistent identifiable set of markings for all automotive fire apparatus; and enhanced aerial control technologies, enabling short jacking and envelope controls.

*Upgrading Fire Apparatus***.** Any apparatus, whether in first-line or reserve service, should be upgraded in accordance with NFPA 1912, as necessary, to ensure that the following features are included as a minimum:

1. Seat belts with seat belt warning systems are available for every seat and are new or in serviceable condition.
2. Warning lights meet or exceed the current standard.
3. Reflective striping meets or exceeds the current standard.
4. Slip resistance of walking surfaces and handrails meets the current standard.
5. A low-voltage electrical system load manager is installed if the total connected load exceeds the alternator output.
6. The alternator output is capable of meeting the total continuous load on the low voltage electrical system.
7. Where the gross vehicle weight rating (GVWR) is 36,000 lb. (16,000 kg) or more, an auxiliary braking system is installed and operating correctly.
8. Ground and step lighting meets or exceeds the current standard.
9. Noise levels in the driving and crew compartment(s) meet the current standard, or appropriate hearing protection is provided.
10. All horns and sirens are relocated to a position as low and as far forward as possible.
11. Signs are present stating that no riding is allowed on open areas.
12. A pump shift indicator system is present and working properly for vehicles equipped with an automatic chassis transmission.

13. For vehicles equipped with electronic or electric engine throttle controls, an interlock system is present and working properly to prevent engine speed advancement at the operator's panel, unless either the chassis transmission is in neutral with the parking brake engaged, or the parking brake is engaged, the fire pump is engaged, and the chassis transmission is in pumping gear.
14. All loose equipment in the driving and crew areas is securely mounted in accordance with the current standard.

Performance benchmarks may be used when developing an apparatus replacement program. Benchmarks can be used to assess and implement a policy to define practical conditions and guidelines for replacement which can be used to project the life cycles of apparatus. Replacement benchmarks reflect operational, technological, downtime, and financial criteria. The following is an example of a replacement point system used for a low-usage, but older pumper apparatus. Continued usage of such apparatus can be justified in some circumstances (Peters, 1994, p. 3).

Table 5.2. Evaluation Criteria for Apparatus Replacement

Factor	Points		
Age	Credit one point for each year of in-service status after 10 years.		
Miles/Hours	Credit one point for each 10,000 miles or 1,000 engine hours.		
Type of Service	Credit one, three, or five points based on the type of service: Engine, rescue, ambulance, command – 5 pts. Ladder, tanker, brush, utility – 3 pts. Non-emergency response vehicle – 1 pt.		
Reliability	Credit one, three or five points based on frequency of repair work. A five would be assigned to a vehicle in the shop two or more times per month on average, while a one would be assigned to a vehicle in the shop an average of once every three months or less.		
M&R Costs	Credit one to five points based on total lifetime maintenance and repair (M&R) costs (not including repair of accident damage). A five is assigned to a vehicle with life M&R costs equal to or greater than the vehicle's original purchase price, while a one is given to a vehicle with life M&R costs equal to 20 percent or less than its original purchase cost.		
Condition	This category takes into consideration body condition, rust, interior condition, accident history, anticipated repairs, and so on. A scale of one to five points is used with five being poor condition.		
Point Ranges	Fewer than 18 Points	Condition I	Excellent
	18 to 22 points	Condition II	Good
	23 to 27 points	Condition III	Qualifies for replacement
	28 points and above	Condition IV	Needs immediate consideration

Example: A 20-year-old pumper is planned for replacement in two to three years. The apparatus has 10,000 miles and more than 4,000-engine hours; is in good condition; and has experienced a moderate amount of downtime, good reliability, and repair costs that exceed more than 30 percent of its original purchase price. The points would be assigned as follows:

Age = 10 points Miles or engine hours = 1 points
Type of service is severe = 5 points Reliability = 2 points
M&R costs = 2 points Condition = 2 points
Total = 22 points and rates as "good condition"

The point system is based on commonly used methodology (Brown, 2013). This scheme above was adjusted to be more realistic for low-usage apparatus.

Specifications. It is recommended the fire department develop specifications for new apparatus using a "performance-based" approach which in some municipalities is a requirement in order to reinforce an objective and fair bidding process. The specifications should be developed broadly

enough to allow manufacturers to incorporate various engineering solutions yet restrictive enough to eliminate an inferior product. Most manufacturers can provide draft basic specifications during the specifications process as well as guidance on relevant standards.

Developing Specifications**.** NFPA 1901 provides minimum technical requirements when specifying new fire apparatus. Many fire departments will want additional features of operation that are in addition to the standard's requirements. It should be remembered that details, such as those items that may exceed the minimum requirements, should be carefully defined in the specifications for the apparatus. Examples include special performance requirements, defining the number of seats and the seating arrangement for fire fighters riding on the apparatus, or providing space for extra hose or equipment the apparatus will be required to carry. Developing specifications can take up to eight or more steps before submitting for bid.

Step 1 – Define Mission/Use. The first step in the design of an apparatus is to define its mission. The department should consider the basic specifications as follows:

1. The type of apparatus to be purchased (pumper, aerial, initial attack, other)
2. Types of responses (structure fires, wildland fires, automobile accidents, suburban environment, downtown city, medical assistance, rural water supply, etc.)
3. The response environment (old city downtown with narrow streets and alleys, suburban neighborhoods, garden apartments, rural roads, major expressways, distances of hundreds of miles, etc.)
4. Crew size (number of seats)
5. Size of pump, if any
6. Size of tank(s), if any
7. Aerial device type and length, if any
8. Hose load, if any
9. EMS capability, if any
10. Commercial or custom chassis
11. Chassis configuration (conventional, cab over, cab forward, rear engine)
12. Size or weight limitations due to firehouse, roads, bridges, terrain, neighborhoods
13. Budget considerations
14. Expected service life (years) and duty cycle (runs per day or month)

Step 2 – List Fixed Equipment. The second step in the design of an apparatus are the permanent, or "fixed" equipment components. These major components most often represent a concentration of the heaviest load elements of the vehicle. It is important these components be identified early in the initial designs and be situated on the vehicle to provide for the following:

1. Good load distribution
2. Balance (both front to rear and right to left)
3. Low center of gravity

Fixed components can be located in exterior compartments or in the interior of the vehicle to be functional and organized in a layout to be user friendly in emergency applications. The following are examples of fixed equipment:

1. Electrical generators
2. Water tanks, fire pumps, and other fire-fighting equipment
3. Air cascades or compressors
4. Reels of all types

Step 3 – List Portable and Fixed Equipment. A significant function of fire apparatus is the storage of equipment including the tools and appliances used in various fire and rescue operations. It is important to remember the weight of this equipment when determining the apparatus' overall gross vehicle weight rating and carry capacity. All portable and fixed equipment should be identified and listed in the following categories:

1. Existing — equipment currently owned that will be carried
2. Proposed — new or additional equipment that will be carried
3. Future — equipment that may be carried in the future

This step will ensure a chassis will be specified with an adequate gross vehicle weight rating that ensures the likelihood the apparatus will not be overloaded in the future.

Step 4. *– Calculate Required Space*. The department should analyze the actual cubic feet (meters) of space necessary for all fixed and portable equipment. Some departments compare comparison equipment to be carried on the new apparatus with the equipment carried on existing apparatus which can demonstrate relative special needs. The actual usable space in compartments should also be considered, in addition to the individual cubic feet (cubic meters) for each item of equipment to be carried. Factors that might increase the required cubic feet (cubic meters) of storage space required and thus the size of the vehicle body include:

1. Compartment door and box pan interference
2. Mounting implications
3. Compartment shelving
4. Slide trays
5. Components of the body such as compartment flanges, notches, and other interferences that affect removal of equipment from compartments
6. Ventilation of generator, air compressor, or other equipment

Step 5 – Local Operating Conditions. The department should carefully define the requirements of local operating conditions that necessitate unusual design criteria. An example is the department whose response area include many narrow, winding streets where apparatus must be capable of easily negotiating switchbacks. Performance criteria may include:

This may include:

1. Apparatus height and/or width
2. Under-vehicle clearance
3. Wheelbase, turning radius and overall length

Step 6. – Safety Requirements. Fire apparatus should be designed to ensure it is capable of good performance, with the inclusion of restrictive features only where needed to specify minimum requirements. Performance and safety tests are an important feature of the specifications process. Specifications should include performance requirements as identified in national vehicle safety regulations. These include the Canadian Motor Vehicle Safety Regulations (C.R.C., c. 1038) and the Standard for Automobile Fire Fighting Apparatus, CAN/ULC-S515-13-R2018.

Step 7. Define Warranty Requirements. Within the specifications, the department should define warranty requirements and should include the manufacturer's responsibilities within a certain time period. Some departments have provisions for a second warranty period beyond the terms of the basic warranty for specific components, such as the engine, pump, frame, and water tank. If a secondary manufacturer is involved in modifying components that are warranted by the original manufacturer, the responsibility for warranty work should be clearly understood by the original manufacturer, the secondary manufacturer, the contractor, and the purchaser. Where applicable, the department may include a warranty bond to ensure that any warranty work will be performed, even if the apparatus manufacturer should go out of business. Warranty bonds are a third-party secured bond established by the manufacturer before delivery of a vehicle to guarantee workmanship, quality of material, or other stated performance of the vehicle components.

Step 8. – Develop Detailed Specifications. After the completion of Steps 1-7, it is recommended the department consult with the municipality's attorney, engineer, fleet services and other appropriate officials for assistance in developing the detailed specifications. NFPA 1901 includes a form for developing *Apparatus Purchasing Specifications* which is found in the standard.

The department should complete only the sections marked with an asterisk (*) and only those sections where there are specific requirements over and above the standard. All the items of information marked with an asterisk (*) generally are required for the manufacturer to bid on and build the apparatus. The other items are details about which the purchaser might want to specify special requirements. In many cases, the purchaser should specify additional details only if the purchaser is experienced in that area and has specific, unusual requirements. Consult with manufacturers or others with experience in apparatus architecture and specifications if necessary. When more restrictive details are specified, fewer manufacturers will be able to bid, and the cost of the apparatus might be higher.

Maintenance and Extended Life Criteria

Preventive Maintenance. NFPA 1911 defines preventive maintenance as the act or work of keeping fire apparatus in proper condition by performing necessary preventive actions in a routine manner to prevent failure or breakdown. With that, apparatus is becoming increasingly complex requiring regular preventive maintenance to keep them safe and reliable while maximizing their life and value. It is not enough just to repair problems when they occur or to perform maintenance when it is convenient or someone thinks to have it done. A good maintenance and service plan is necessary in order to keep a fleet of fire apparatus in good condition.

The needs of a fire departments vary widely including their requirements of a preventive maintenance program. At one end of the spectrum might be a small rural volunteer fire department with two apparatus responding to five incidents per month. At the other end might be a large city with several hundred apparatus, each of which makes 10 or more incidents per day. While the specifics of the preventive maintenance program for each department will be different, the goals in each should be to ensure that all the necessary preventive maintenance is performed to make certain that the apparatus is ready and safe for responding to a fire or emergency when needed. It is important that each department develop a program appropriate for its apparatus, circumstances, resources, capabilities, and special circumstances.

It is imperative that all apparatus be checked and maintained regularly to ensure that they will be reliable and safe to use. Manufacturer guidelines should always be followed when maintaining the fire apparatus with special attention being paid to ensure that the following conditions, which are particularly critical to maintaining a reliable unit, are addressed:

1. Engine belts, fuel lines, and filters have been replaced in accordance with the manufacturers' maintenance schedule(s).
2. Brakes, brake lines, and wheel seals have been replaced or serviced in accordance with the manufacturers' maintenance schedule.
3. Tires and suspension are in serviceable condition, and tires are not more than 7 years old.
4. The radiator has been serviced in accordance with the manufacturer's maintenance schedule, and all cooling system hoses are new or in serviceable condition.
5. The alternator output meets its rating.
6. A complete weight analysis shows the fire apparatus is not over individual axle rating or total GVWR.
7. The fire pump meets or exceeds its original pump rating.
8. The water tank and baffles are not corroded or distorted.
9. If the apparatus is equipped with an aerial device, a complete test to original specifications has been conducted and certified by a certified testing laboratory.
10. If so equipped, the generator and line voltage accessories have been tested and meet the current standard.

Resources. When developing a preventive maintenance program, it is important to identify resources that are available for maintenance and testing. Some large city departments there are extensive facilities in a fire department or city public works shop. Even in such a department, some work, such as transmission overhauls and body work, might be sent to outside service facilities. Generally, fire department personnel who operate the apparatus can, in most cases, perform daily or weekly operational checks.

Most often preventive maintenance services are provided under contract by an outside source such as emergency vehicle maintenance businesses or through the department municipality's fleet services unit. Often these services often can be performed in the fire station with mobile service trucks. Qualified personnel who perform service on other types of heavy trucks can perform many types of service on emergency vehicles, especially on components common with heavy trucks, such as drivetrains and suspensions.

Other departments, especially volunteer departments, might find that they have personnel in the department who are qualified to do some of the required maintenance. These resources can be used to perform some of the maintenance and reduce costs. It is helpful to identify not only the resources that will perform routine preventive maintenance and testing but also resources to perform emergency repairs. If such resources are not available within the department or municipality, these resources should be identified in advance, including establishing financial arrangements and 24-hour contact information, if possible. Services that should be included are as follows:

1. Towing
2. Tire service or replacement
3. Provision of fuel and lubricants
4. Repair of engine and drivetrain problems
5. Repair of pump or plumbing problems
6. Repair of fire service components, such as rescue tools
7. Supplying replacement hose, tools, gear, and equipment damaged at an incident

Form and Format. An effective preventive maintenance program can take many forms. It is important that maintenance records are easy to keep updated as apparatus is replaced, and that it is easy for the fire department and the maintenance providers to use. Most often there are two types of information needed when establishing the preventive maintenance program. The first is when maintenance is needed, and the second is what maintenance tasks should be performed and, if necessary, how they should be performed. Scheduled preventive maintenance activities are typically based on time (every 3 months, every 6 months, annually, and every 5 years) or a specified number of hours of operation.

For smaller departments this be a monthly schedule describing which apparatus is due for service and which service is to be performed at that time. It is important the schedule be updated whenever an emergency vehicle is added or removed. A larger department might find it more functional to prepare a schedule by month or by number of hours for each piece of emergency vehicle. There are many records management software programs available to assist in tracking maintenance schedules.

A preventive maintenance program should always begin with regular operational checks that are to be performed at the start of each day, shift, or week are usually best documented with a check sheet to be used by the station crew. The performance testing described in NFPA 1901 should be included in the preventive maintenance schedule. The details of how to perform the testing, and the information that is to be collected, are detailed in the respective chapters of the standard.

Program Implementation. The preventive maintenance program for any specific apparatus, or for a department, needs to include requirements from several sources. Included are the manufacturer's manuals. If the manuals that should have been delivered with the emergency vehicle when it was new are not available, contact the original manufacturer to determine if duplicates are available. If the manuals are not available, maintenance recommendations for specific components, such as engines and transmissions can be obtained from their manufacturers. Manuals should be carefully reviewed for recommendations for inspections, lubrication, replacing parts, testing, or other periodic maintenance tasks as well as specifications

needed for confirming proper operation in the performance testing. Another source are the requirements of NFPA 1901, 1911 and 1912.

All forms of maintenance records should be kept for the life of the apparatus. This can be done by creating a filing system or other mechanism for retaining records. All records should be maintained by apparatus so that they can be delivered with the apparatus when it is sold. In many cases, problems can only be detected by comparing current test results with previous test results. For these problems to be detected, it is important that the records be well organized and available for future review. In the event of an accident, the accident investigation will include a review of all maintenance records.

Extended Life. When a department is developing specifications and comparing bids from manufacturers, consideration should be given to the costs of operating and maintaining the apparatus. As an example, the addition of a heavy-duty drive train component may extend the life of an apparatus or reduce maintenance costs for the life of the vehicle. A minimal initial investment can help reduce ongoing costs throughout the life of the apparatus.

NFPA 1912 - Standard for Fire Apparatus Refurbishing. NFPA's Standard 1912 specifies the minimum requirements for the refurbishing of fire apparatus utilized for firefighting and rescue operations, whether the refurbishing is done at the fire department or municipal maintenance facilities, or at the facilities of private contractors or apparatus manufacturers. The standard, in conjunction with NFPA 1901 and 1911 can provide the framework for extending the life of an apparatus.

Refurbishing scope is broken down into two levels:

Level I – Refurbishing is intended to meet the current edition of NFPA 1901.
Level II – Refurbishing is intended to meet the edition of NFPA 1901 that was in effect when the apparatus was originally constructed.

3.3.42.1* Level I Refurbishing. The assembly of a new fire apparatus by the use of a new chassis frame, driving and crew compartment, front axle, steering and suspension components, and the use of either new components or components from an existing apparatus for the remainder of the apparatus.

3.3.42.2* Level II Refurbishing. The upgrade of major components or systems of a fire apparatus with components or systems that comply with the applicable standards in effect at the time of upgrade.

Alternative Approaches

Standardization. Because of the long service life of fire apparatus, it is difficult to provide units that have standard ways of storing and using equipment and standard operating methods. However, to the extent possible, for efficiency and cost effectiveness, apparatus can be standardized with uniform layouts to allow for equipment and tools to be stored in a particular location.

The fire apparatus manufacturing industry has a long history of longstanding and reliable companies failing and newer companies being established and then failing. The survival of any one manufacturer cannot be absolutely guaranteed for the life of the warranty, much less the service life of the apparatus. A fire department, along with municipal officials can take several steps in minimizing risks.

First, good specifications can be developed that are based on local needs and experience within the broader spectrum of national standards. An apparatus prototype that is designed well can go a long way toward providing a vehicle that will serve the community.

Second, to the extent possible, the department should not use apparatus components that are handmade or bought on special order. Later in the life of the apparatus these parts and components will become scarce or difficult to obtain. Another consideration where practical is the use of components and parts that are in general use of the trucking industry. These parts will remain available, whereas custom fire apparatus parts may become difficult to find.

Purchasing Consortiums. Related to standardization of apparatus specifications is where multiple fire departments purchase apparatus through a multi-agency purchasing consortiums. This "economy of scale" approach has been successful when multiple fire departments purchase apparatus from the same specifications thus reducing the cost per apparatus unit. The practice has been successful when regional organization such as a fire chief association serves as the anchor for the development of a consortium who can partner with provincial-level agencies that have experience and expertise in developing apparatus specifications, developing bid proposals and managing blanket contracts for large volume purchases.

Vehicle Inspections

NFPA 1911, "*Standard for the Inspection, Maintenance, Testing, and Retirement of In-Service Emergency Vehicles*." The Standard contains sample vehicle inspection forms and step by step guidance on how to conduct an inspection on different types of fire apparatus and all separate systems contained on the apparatus.
The best practice would be for the fire department to adopt the criteria set forth in NFPA 1911 as its inspection criteria. Vehicle Inspection is a critical task to assure the operational readiness of the vehicle and all the tools and equipment carried on the vehicle.

The frequency of the Vehicle Inspection is somewhat dependent on the type of fire department and the alarm frequency of the department. In career or combination fire departments generally, there is a daily or beginning of shift inspection and a more comprehensive weekly inspection.

Volunteer departments would typically inspect weekly, with extra inspections during extreme weather or periods of high demand. For all volunteer departments with low alarm frequency, the same types of inspections should be performed. The period between inspections may be extended. The weekly inspection could extend to a monthly inspection.

The chauffer or operator generally performs the daily or shift change inspection This inspection would include a 360 degree walk around of the vehicle, noting any damage found, assuring all outside carried equipment is secured, pump is wet, water tank is full, glass, lights and mirrors are clean, seat adjusted, mirrors adjusted for rear visibility, all equipment in cab is secured.
The weekly inspection should involve all personnel assigned to the unit. A thorough inspection of the apparatus and all the tools and equipment carried on the unit is conducted.

There should be a Master Inventory of all tools and equipment assigned to and carried on the unit. If there is a serial or inventory number assigned to an item, that number should be listed on the Master Inventory, as well.

An efficient method to conduct the inspection is by compartment or location on the vehicle. As an example, a fire engine may carry multiple sets of hose spanner wrenches at separate locations on the unit. Rather than hopscotching around the vehicle to account for each set, the spanners would be accounted for by location. If one set is in the left front compartment, then it would be checked for when checking all the equipment stored in the left front compartment. The inventory sheet could be laid out by compartment or vehicle location. Also, a laminated sheet listing all tools and equipment by compartment or location could be created. Each member could be given a sheet for a compartment to be checked. Any exceptions can be reported to the officer in charge and noted on the inspection report form.

For the inspection of the vehicle itself, a check list should be created. A good practice is to create the form so that a **YES** or **OK** response indicates the normal or proper operating conditions, and a **NO** response indicates an abnormal or improper operating condition. The **NO** response would also trigger the need for an action such as correction by the operator, work order entered for minor repair, or placing the unit out of service if a serious safety condition was found.

An example of an operator correction is if the policy is that the fuel level is at ¾ tank or greater, and the fuel level is at ½ tank, then the Fuel Level at or above ¾ 3sponse would be **NO**. The Operator would fuel the vehicle per policy and note unit fueled, *x* gallons and record the mileage. All on rig auxiliary equipment such as generators should be started and run under load for a period. All small gasoline engine powered equipment should be checked for proper fuel, proper operating condition, started and operated for a period.

All battery-operated equipment should be checked to assure that batteries are charged, and the unit is operating properly.

Departments may already have inspection programs and forms in place. Links to sample inspection forms in use by some departments are available in the Appendix.

Cold Weather Operations

Given Canada's northern latitude location, the possibility for pump freeze-up during periods of extreme freezing weather is real. Actions that may be taken to prevent pump freeze-up include:

- Draining the pump of water during winter operations.
- Engaging the pump and circulating tank water through the pump when the apparatus is outdoors and stationary.
- Specifying a pump housing heater in the vehicle specification.

Draining the pump during winter operations:

Draining the pump and running with it "dry" seems to be the easiest and most cost-effective method of protecting the pump from freeze up. If this option is selected, care must be taken to assure that all water has been drained from the pump. With all the fittings and piping, the possibility of some water remaining in the pump is real. Once all valves except tank fill and pump to tank valves have been opened and water drained via the main pump drain, all valves should be shut (Avsec, 2013).

Driving the vehicle is a good practice so that any trapped water may slosh to the bottom of the pump. Reopen the main drain and check for water flow. If there is significant flow then there is the possibility of a leaking tank fill or tank to pump valve. Check both for proper operation & repair/replace, as necessary.

Compressed air can be used to force any remaining water out of the pump. Departments may already have a 2 ½" female to garden hose thread male adaptor for wash down of personal protective gear after incidents. If so, a garden hose female to air chuck adapter can be easily and inexpensively fabricated. Another option for discharging any remaining water from the pump is to fabricate a 2 ½" blind cap with an air chuck valve tapped into it.
Placing the adapter on a 2 ½" discharge and open the discharge valve and the main drain valve. Place a compressed air line onto the air chuck valve and charge the pump cavity with compressed air. The pressurized air should displace any standing water and it will gravity flow out the main pump drain valve.

A common practice is to leave the pump drain valve(s) in the open position while the engine is in the firehall. The operator returns all pump drain valve(s) to the closed position before departing whenever the engine leaves the firehall. This practice prevents the chance of any remaining water passing by the open drain valve and freezing it in the open position, thus putting the engine out of service.

Engaging the pump and circulating water:
If ambient temperatures are well below freezing, then operating with a dry pump is the best practice.

In areas where temperatures hover just a bit under freezing then engaging the pump and circulating water through it and the tank should be a standard operating procedure whenever units with a wet pump arrive on scene. Engaging the pump and opening both tank to pump and

tank fill valves with the engine operating at idle will circulate water and avert pump freezing. If there is no tank fill valve, if there is a booster line, placing the booster line nozzle into the booster tank top inspection opening and flowing water will accomplish the same. If no booster line, then fabricating a garden hose male thread tapped into a 2 ½" blind cap with a short length of garden hose flowing water into the tank top inspection opening will work, as well.

Pump Compartment Heat

In areas with severe winter weather conditions, installation of a supplemental heat system to warm the pump compartment along with enclosing the underside of the pump compartment with heat shielding is common.

Three options for providing heat are:

- Using the vehicle engine coolant system
    - Using engine coolant system: Supply and return lines connect from the engine's coolant system to and through heating manifolds installed in the pump compartment. The warm coolant conducts to the manifold's fins to provide heat to the pump compartment.
- Install electric heaters
    - Radiant electric heaters are installed in the pump compartment with power from the vehicle's electrical system.
- Install small engine heaters
    - Diesel fired auxiliary heater is installed in the pump compartment

With any of the above methods, electric powered fans are also installed to circulate the warm air from the heating device throughout the pump compartment.

Fire Hall Heat Monitoring

Beyond the scope of this report, it is worth mentioning that a system to assure the fire hall heating system is operational should be in place. For departments where the fire hall is occupied every day, this is not an issue. In volunteer departments where the station is usually unoccupied except for alarms and meetings, a method to assure the firehall heating system is operational should be instituted.

A cost-effective method (though prone to failure) is for a department member to visit the station each day and verify that the heating system is working. A clipboard with a daily temperature check and sign in by the member checking is the simplest. An improved system contains oversight whereby the member checking the firehall calls a designated department member and confirms that the heating system is working with a second member.

Other methods involve monitoring of the firehall heating system or inside ambient temperature. If the heating system goes out and the inside air temperature drops below the threshold alarm activation temperature, the system activates and transmits an ALARM or TROUBLE signal condition. Examples of where the notification of the Low Temperature condition could report using available technology are:

- Firehall exterior alarm activation
- Central Monitoring Station
- Member's cell phone via text alert
- Combinations of the above

The department's Continuity of Operations Plan, COOP Plan, should address actions to take. Issues it should address should include:

- Rapid troubleshooting and repair of the firehall heating system.
- Acquiring a temporary auxiliary heating system for the firehall.
- Relocating the fire apparatus to a backup heated facility and taking steps to mitigate freeze damage at the firehall until the return of an operating heating system.

VI: Alternate Fire Protection Delivery Concepts

Although not explicitly related to fire apparatus specification, we believe that there is a consensus both in the literature and in practice, that investments in fire apparatus, while necessary and appropriate, are not always the most effective ways to reduce the toll of fire loss in communities. This challenge is doubly apparent in the resource-constrained environment of First Nations communities.

The report illustrates important considerations in specification and maintenance of fire apparatus in First Nations communities. While these criteria can and should be used to plan for apparatus condition assessments and documentation of local fire service capabilities, the challenges of applying these criteria become more challenging in communities with lower dwelling protection grades.

Apply Risk-Based Principles

Focusing on provision of FUS-compliant fire apparatus should be viewed as a critical component of a comprehensive fire-risk reduction program, building on previous and ongoing work by NIFSC (Heusken, Xiao, Jennings, & Dow, 2020). Community risk factors, to include demographic, socioeconomic, and building stock risk can be used as a basis to justify allocation of fire apparatus. As part of this process, viability of local fire services should be measured to identify communities' level of human and organizational resources.

Table 6.1 assembles these community risk factors with criteria for fire service resources and capabilities.

Table 6.1 Elements of Apparatus Decisions

Community Fire Risk	**Current Apparatus**	**Fire Service Staffing**	**Building Stock**
Demographic	Number and Type of Apparatus	Membership size	Number
Socioeconomic	FUS Recognition	Interior Trained Members	Size
Environment	Apparatus Age/Condition	Training	Built-in Protection
Demand for Service		Equipment	Density/Exposures

.

The cost-benefit framework developed by NIFSC (Clare & Robinson, 2021) can be used to inform decisions about investments in apparatus, particularly in those communities that currently do not have FUS-recognized fire services, informed by the risk identification.

While much of the apparatus purchase and replacement process should continue with refinements for specification and placement according to community needs. These decisions

should be mindful of FUS requirements in order to maintain or improve ratings, and economize, where appropriate, to recognize extension of lifespan of existing apparatus.

Develop FUS Guidance to Recognize Alternate Risk-Based Approaches

We recognize that many communities have sufficient resources and size to enable provision of viable or even thriving fire services and building fire safety mitigation activities. However, there are a large number of communities where the burdens of maintaining a trained force to staff a fire service is a challenge.

Non-traditional fire apparatus, namely Mini-Pumpers, Rapid Intervention Vehicles, and alternate or novel fire extinguishing technologies can potentially play decisive roles in bridging the gap between the demanding standards of an interior-certified, trained, and staffed fire services and the emergent needs for infrequent, but nonetheless critical fire suppression. Of particular concern is the case of fire services that may lack equipment or staffing or both to meet the requirements for recognition under the FUS. For these marginally-staffed fire services, application of alternative fire apparatus that places reduced demands on staffing and training (as compared to operation of traditional fire apparatus) should be explored.

These needs are apparent in the low-frequency/high consequence events such as structural fires that occur in geographically-isolated, smaller communities that may not be able to support a full-fledged fire service designed to support interior structural firefighting.[2] Guidance is available for training standards and levels at "exterior-only" operations (Office of the Fire Commissioner, 2015).

We advocate for engagement by FUS in communities currently unable to meet requirements for recognition of a local fire service (Class 5). The NIFSC should work to apply its recently-developed guidance to systematically assess risk and develop interventions across its various dimensions in those communities with the least fire suppression resources. It is in these communities that the greatest potential benefits from trade-offs between preventive and suppression resources are most stark.

Specifically, the FUS could establish criteria for recognition of alternative fire suppression capability, and strategic built environment protection and preparedness. For example, a settlement equipped with a low-impact RRV, a cadre of trained operators, and fire detection and alerting capabilities might qualify for some recognition in terms of insurance reductions.

We do not address the limited penetration of formal fire and property insurance into First Nations communities, but believe expansion of coverage can provide incentives for improved fire protection and more rigorous loss control measures. Those communities operating under effective self-insurance schemes are obviously not incentivized under these mechanisms (Maxim, 2021).

[2] This challenge is not unique to First Nations. The prospect of more limited capability fire service was raised in other settings in Canada. See Manitou, Inc. *Development of Benchmarks for the Fire Service Liaison Group* FSLG ToR 1, 2008.

There are several groups working on applied fire safety research in low-resource developments. Some of this work may be complimentary to the efforts of NIFSC. These include recent efforts devoted to fire safety in informal settlements and the developing world. Although not an exact alignment, there may be areas of mutual benefit, particularly in the area of non-traditional fire detection and alerting, and community-based fire prevention work (Arup, 2018; Kindling, 2021).

IoT and Emerging Technologies

The last area of alternate fire protection concepts is the application of emerging wireless technology to fire safety. Collectively defined as "smart firefighting" (Grant, Hamins, Bryner, Jones, & Koepke, 2015). Specific to the area of fire detection and alerting or reporting, there is ongoing research to leverage low-cost sensors for fire detection.

There are also several commercially-available consumer technologies for interconnection of smoke detectors that include features such as wireless notification to app-equipped smartphones. Such technologies offer promise for adaptation to challenges facing First Nations communities.

A complementary use of technology is in the area of equipment readiness and establishing the presence of and alerting of firefighting personnel. There are commercial applications available to allow dispatch via cell phone, polling of members to determine availability, tracking of response times. Such applications could be useful for establishing the availability of firefighters and justifying credits toward insurance recognition.

This effort should not preclude pursuit of low-tech, high-reliability systems to include public warning systems, wired alarm reporting systems, or other well-established technologies.

VII: Conclusion

The National Indigenous Fire Safety Council Project is studying fire protection in First Nations communities across Canada. This report was intended to provide background on industry requirements for fire apparatus specification, longevity, and explore possible alternatives apparatus that might be better suited to the unique applications of First Nations communities.

The report has identified that non-traditional apparatus and extinguishing technologies may be appropriate and improve the level of fire safety in some communities. We concur that insurance-based or recognized incentives for non-traditional fire protection can be useful as a means to improve fire safety through interventions not currently recognized by the Fire Underwriters Survey.

We also suggest some policy interface with recent and ongoing efforts by NIFSC in the areas of insurance, community risk reduction, and firefighter training. Collectively, we believe these offer great promise for enhancing safety through more effective firefighting, earlier fire detection, and reduced incidence of adverse fire-related events.

We conclude with the following recommendations:

1. Work with FUS to develop a special grade of dwelling protection for rural, remote, and First Nations settlements currently classified as “5” (Unprotected). This would incentivize sound investments in community fire protection to encompass risk reduction and provision of fire suppression equipment or services with less than 15 auxiliary firefighters.
2. Explore the use of novel extinguishing agent Rapid Response Apparatus for use by fire departments with limited membership and/or insufficient interior-trained personnel. A formal evaluation of tradeoffs between UHP and CAFS units should be conducted – the research in this report is not conclusive, but both technologies are worthy of exploration and evaluative deployment.
3. Study technological alternatives for community-based measures to monitor and alarm for early warning fire detection devices. These would include alarm monitoring and reporting technologies leveraging IoT, infrastructure to limit chance of fire spread beyond the structure of origin, and aggressive use of fire suppression systems in critical facilities and large structures. Availability of broadband or proprietary networks should be assessed.
4. Gather data on maintenance and utilization of fire apparatus to develop best practices for replacement and refurbishment.
5. Use holistic community risk analysis to balance investments in fire apparatus versus potentially more effective interventions, especially in communities with marginal or minimal fire services available.

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VIII: Appendices

A1: List of Fire Apparatus and Equipment Manufacturers

Manitou Inc. does not endorse any fire equipment manufacturer or supplier. The listing of the URLs below is provided for the reader to learn more about the vehicles and extinguishing systems, as well as features and options available. The listing may not be inclusive. Any entity considering the purchase of firefighting unit or equipment should conduct its own due diligence and develop a Bid Specification for the vehicle that will meet the needs of the community.

Ultra High Pressure Equipment Manufacturers

Name	Address	Types of Applications	Website
HMA FIRE	Ocala, FL 608-444-5491	Integrate into existing or new apparatus, Mini Pumper Skid Mount	www.hmafire.com
Kimtek	Orleans, VT 888-546-8358	Skid mount	www.kimtekresearch.com
EJ Metals	New London,WI 920-779-9913	Mini Pumper, Skid Mount	www.ejmetals.com
Rosenbauer	Wyoming, MN 8651-462-1000	Mini Pumper, Skid Mount	www.rosenbaueramerica.com

Fire Pump/Compressed Air Foam Manufacturers

In addition to their standard line of fire pumps, Darley, Hale, and Waterous pump manufacturers all have Compressed Air-Foam System, CAFS options in their respective product lines.

Name	Address	Telephone	Website
CET Fire pumps	75 Hector St PO Box 90 Pierreville, QC	888.844.2285	www.fire-pump.com
Darley	325 Spring Lake Drive, Itasca,IL	800-323-0244	www.darley.com
Hale	607 NW 27th Ave Ocala, FL34475	800-533-3569	www.haleproducts.com
Waterous	125 Hardman Ave S. St. Paul, MN 55075	651-450-5000	www.waterousco.com

Fire Apparatus Manufacturers

Name	Address	Types of Apparatus	Website
4Guys	230 Industrial Park Rd Meyersdale, PA 15552 814-634-8373	A, CAFS, CE, COE, M, R, T	www.4guysfire.com
Boise Mobile Equipment	5656 W. Morris Hill Rd. Boise, ID 83706 800-445-8342	CE, COE, R, T	www.bmefire.com
Carl Thibault	38 Rue Thibault, Pierreville, QC 450-568-7020	A, CE, COE, M, R, T	www.thibaultfiretrucks.com
E-One	Ocala, FL 352-237-1122	A, CE,COE, M,R,T	www.e-one.com
Ferrara	27855 James Chapel Rd N Holden, LA 70744 800-443-9006	A,CE, COE, R, T	www.ferrrafire.com
Fort Garry	RR@, 53 Bergen Cutoff Road, Winnipeg, MB R3C 2E6 800-565-3473	A, CE, COE, R, T	www.fgft.com
Fouts Bros. HME-Ahrens Fox	2158 Atlanta Rd SE, Smyrna, GA 30080 844-394-0010 1950 Byron Center Ave SW Wyoming, MI 49519 616-534-1463	COE, M, T A, CE, M, R, T	www.foutsfire.com www.firetrucks.com
Hub	3175 McCallum Road, Abbotsford, BC V2S 7W5 604-859-3124	CE, COE, M, R, T	www.hubfire.com
KME	500 E. Catawissa St. Nesquehoning, PA 18240 800-235-3928	A, CE, COE,M, R,T	www.kmefire.com
Pierce	2600 American Drive, Appleton, WI 54914 920-832-3000	A, CE, COE, M, R, T	www.piercemfg.com
Rosenbauer	PO Box 549 Wyoming, MN 55092 8651-462-1000	A, CE,COE,M,R,T	www.rosenbaueramerica.com

Seagrave	105 E12th St. Clintonville, WI 54939 715-823-2141	A, CE,COE, R	www.seagrave.com
Smeal	610 W 4th St. Snyder, NE 68664 402-769-2273	A	www.spartaner.com
Spartan	907 7th Ave N Brandon, SD 57005 517-588-4700	A,CE, COE, M, R, T	www.spartaner.com
Sutphen	Dublin, OH 800-726-7030	A,CE,COE, M, R,T	www.sutphen.com
Unruh	201 E Industrial Drive Sedgewick, KS 67135 316-772-5550	M, R	www.unruhfire.com
Darley	325 Spring Lake Drive Itasca,IL 800-323-0244	A, CE, COE, M,R	www.darley.com
QTAC	1072 Marauder St Suite210 Chico, CA 95973 888-797-5100	M, R, S	www.qtacfire.com
SVI	3842 Redman Drive Fort Collins, CO 80524 970-297-7002	CE, COE, M, R, T	www.svitrucks.com

Type of Apparatus Key

A	Aerial	CE	Custom Engine
COE	Commercial Engine	Mini	Mini Pumper
R	Rescue	S	Skid Mount
T	Tanker/Tender		

Tracked Vehicle Manufacturers

Name	Address	Telephone	Website
Arctic Tracks Ltd. #	Box 2382 Yellowknife, NT X1A 2P8	867-873-4334	www.arctictracks.com
Foremost	1225 64th Ave NE, Calgary AB T2E 8P9	403-874-7288	www.foremost.ca
Power Bully	8850 Double Diamond Parkway, Reno NV 89521	775-857-5000	www.powerbully.com
PowerTraxx	150 Regional Road 10, Whitefish, ON P0M 3E0	705-866-4426	http://powertraxx.com
Track Industries Ltd	5529 #rd ST. SE, Calgary AB T2H 1K1	888-255-5323 403-255-1101	www.trackindustries.com
Low Impact	PO Box 547 Highway 43 West Range Road 224 Valleyview, AB T0H 3N0	780-524-4200	www.lowimpact.com
UTV International	8650 Chem. Darnley, Mont-Royal, H4T 1M4	800-985-8665 514-345-0990	www.utvint.com

A2: Sample Apparatus Inspection Forms

The following forms or references are included for informational purposes only. Apparatus inspection programs, including daily checks should follow manufacturer's recommendations.

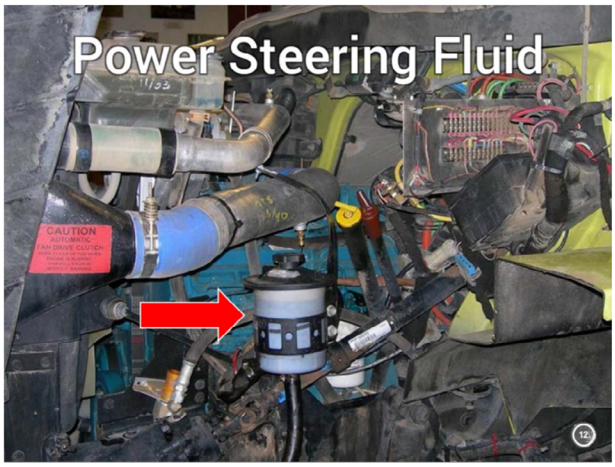
NFPA 1911, *Standard for the Inspection, Maintenance, Testing, and Retirement of In-Service Emergency Vehicles* (2017), which is being incorporated into NFPA 1910, *Standard for Marine Firefighting Vessels and the Inspection, Testing, Refurbishing, and Retirement of In-Service Emergency Vehicles*, which is due for publication in 2024.[3]

This information does not assure compliance with any regulatory standards that may be in effect locally.

The following example forms are drawn from government or publicly-funded sources. In addition to these forms, the reader is directed to the United States Bureau of Land Management, which has manuals and training materials directed at operators of engines of the type that may be common on First Nations communities.

Of particular interest are amply-illustrated guides that are specific to apparatus being used, which also contain guidance on locating components and desired levels, indicators, and settings (see Figure A2: 1 drawn from *Fire Engine Maintenance Unit 1B: Inspections.* ENOP - Vehicle Inspections Job Aid (nifc.gov).

Figure A2:1 Sample BLM Vehicle Maintenance Instructional Illustration



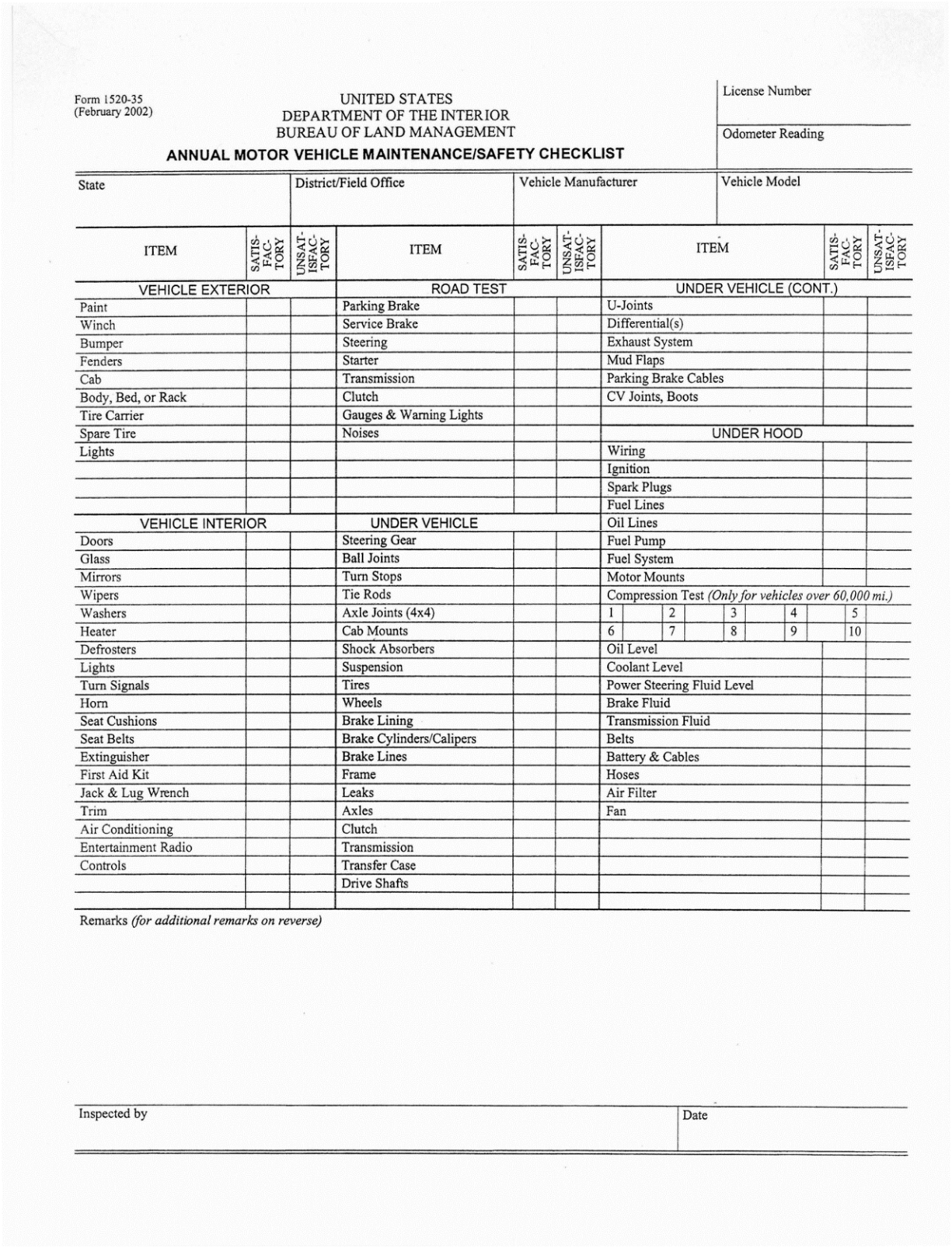
Source; (US Bureau of Land Management, 2021)

[3] NFPA 1910: Standard for Marine Firefighting Vessels and the Inspection, Maintenance, Testing, Refurbishing, and Retirement of In-Service Emergency Vehicles

National Volunteer Fire Council Apparatus Inspection Form (adapted)

Date			Odometer		
Vehicle Model/Unit Number			Vehicle Manufacturer		
Vehicle Exterior			**Vehicle Interior**		
Item	Pass	Fail	Item	Pass	Fail
Cab			**Engine**		
Windshield			Leaks/Puddles		
Windshield wipers			Hoses		
Windows			Oil level		
Doors			Coolant level		
Compartment doors			Power steering fluid		
Head Lights			Belts		
Blinkers			Engine pump		
Brake lights			**Cab**		
Emergency lights			Oil pressure gauge		
Tool mounts			Temp. gauge		
Suspension			Air gauge		
Springs			Voltmeter		
Mounts			Steering play		
Shock absorbers			Horn		
Wheels			Heater/defroster		
Rims			Brake test		
Tires			Seat belt		
Hub/ axle seals			Parking brake		
Lug nuts					
Brakes			Mile Service		
Brake liner			**Hours/Miles _____ Date Completed**		
Brake chambers			Oil Change		
Brake lines			Oil Filter		
Slack adjusters			Fuel System		
Steering			A/C Filter		
Steering box			Lubrication		
Steering box hoses			Other Required Maintenance		
Steering linkage					
Undercarriage					
Fuel tank			**Remarks:**		
Drive shaft					
Exhaust system					
Mud flaps					
Other					
Batteries					
Fire extinguisher					
Road triangles			**Inspectors Signature:**		

United States Bureau of Land Management Inspection Form



Form 1520-35
(February 2002)

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT

ANNUAL MOTOR VEHICLE MAINTENANCE/SAFETY CHECKLIST

License Number

Odometer Reading

State	District/Field Office	Vehicle Manufacturer	Vehicle Model

ITEM	SATIS-FAC-TORY	UNSAT-ISFAC-TORY
VEHICLE EXTERIOR		
Paint		
Winch		
Bumper		
Fenders		
Cab		
Body, Bed, or Rack		
Tire Carrier		
Spare Tire		
Lights		
VEHICLE INTERIOR		
Doors		
Glass		
Mirrors		
Wipers		
Washers		
Heater		
Defrosters		
Lights		
Turn Signals		
Horn		
Seat Cushions		
Seat Belts		
Extinguisher		
First Aid Kit		
Jack & Lug Wrench		
Trim		
Air Conditioning		
Entertainment Radio		
Controls		

ITEM	SATIS-FAC-TORY	UNSAT-ISFAC-TORY
ROAD TEST		
Parking Brake		
Service Brake		
Steering		
Starter		
Transmission		
Clutch		
Gauges & Warning Lights		
Noises		
UNDER VEHICLE		
Steering Gear		
Ball Joints		
Turn Stops		
Tie Rods		
Axle Joints (4x4)		
Cab Mounts		
Shock Absorbers		
Suspension		
Tires		
Wheels		
Brake Lining		
Brake Cylinders/Calipers		
Brake Lines		
Frame		
Leaks		
Axles		
Clutch		
Transmission		
Transfer Case		
Drive Shafts		

ITEM	SATIS-FAC-TORY	UNSAT-ISFAC-TORY
UNDER VEHICLE (CONT.)		
U-Joints		
Differential(s)		
Exhaust System		
Mud Flaps		
Parking Brake Cables		
CV Joints, Boots		
UNDER HOOD		
Wiring		
Ignition		
Spark Plugs		
Fuel Lines		
Oil Lines		
Fuel Pump		
Fuel System		
Motor Mounts		
Compression Test *(Only for vehicles over 60,000 mi.)*		
1 2 3 4 5		
6 7 8 9 10		
Oil Level		
Coolant Level		
Power Steering Fluid Level		
Brake Fluid		
Transmission Fluid		
Belts		
Battery & Cables		
Hoses		
Air Filter		
Fan		

Remarks *(for additional remarks on reverse)*

Inspected by	Date

Source: [Annual Motor Vehicle Maintenance/Safety Checklist (nifc.gov)]