APPENDIX 16

CORRESPONDENCE FROM ENBRIDGE CONSUMERS GAS

500 Consumers Road,
Toronto ON M2J 1P8
Tel 416 495-5489
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ENBRIDGE
Consumers Gas

fax

File Number:

To: Earnes Onyido	From: Brian Black
Organization: Paradigm Engineering Group	No. of pages (including this cover): 1
Department:	Date: 1999-05-21
Fax: Recipient 416-335-1449	If this transmission is not received in good order, please call: Sender 416-495-5489

Re: Metro Toronto Zoo – Natural Gas Supply and Piping

As I had verbally informed you, The pipe on the property of the Metro Toronto Zoo is owned by the Zoo and does not fall under the jurisdiction of Enbridge Consumers Gas. This means that Enbridge Consumers Gas is only able to provide information regarding the gas that is supplied to the system on the Zoo property.

Concerning the present load which is utilized by the zoo under peak hour conditions as supplied by Enbridge Consumers Gas is 1050 M^3 / Hr at a maximum of 45 psi. This pressure could be boosted to deliver 60 psi to the zoo system. The maximum supply that could be provided using present equipment would be 3000 m^3/ Hr. This increase however may be limited by the downstream Zoo piping system. An evaluation should be made by the Metro Toronto Zoo to establish whether any increase in capacity delivered by Enbridge Consumers Gas will be acceptable for the zoo's piping system.

As I mentioned previously, there has been no corrosion survey performed on the Zoo's system in approximately the last 12 years. A leak survey however, is completed annually and was completed three weeks ago for 1999. The results of the leak survey identified no leak indications. It is recommended that a corrosion survey be completed by the Metro Toronto Zoo the secure the integrity of the system and identify any upgrades required in the cathodic protection of the plant.

Please contact me if you have any further questions.

Brian Black

APPENDIX 17

CORRESPONDENCE FROM GRAIG ROSE OF MARSHALL MACKLIN MONAGHAN CONSULTING ENGINEERS

18-93081
memo to file
metro toronto zoo

I spoke with Andy Empringham from Scarborough Fire Prevention on Feb. 14 1995. He said that he sent a copy of my Jan. 19 submission to his fire inspector at the City of Scarborough (Steve Doran). He said that they see our design as an improvement to the existing system and will not require the existing mains to be upgraded. He said that he has the final say on this issue and that there was no need for him to provide a letter to me.

Craig Rose

18-93081-03-SU1

Post-it™ Fax Note 7671E	Date MAY 19/99	# of pages ▸ 2
To ERNEST ONYIDO	From CRAIG ROSE	
Co./Dept	Co. MMM	
Phone #	Phone #	
Fax # 416 3351449	Fax #	

APPENDIX 18

FIRE PROTECTION WATER SUPPLY GUIDELINE FOR PART 3 IN THE ONTARIO BUILDING CODE

DRAFT

Office of the Fire Marshal

OFM-TG-07-98

FIRE PROTECTION WATER SUPPLY GUIDELINE FOR PART 3 IN THE ONTARIO BUILDING CODE

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TECHNICAL GUIDELINE

October 1998

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ABSTRACT

This guideline will assist those trying to establish an adequate fire protection-water supply for new and renovated Part 3 buildings as required by Article 3.2.5.7. or Part 11 of the Ontario Building Code. The criteria for "adequate water supply" will be detailed and the limitations of this criteria explained. Several other factors will be explained as they relate to the fire protection water supply, such as the fire department, environmental impact and cost.

The guideline provides a method of simple calculation of an on-site water supply, taking into account building occupancy, size, construction and exposure, as well as minimum water duration requirements. Other issues that may effect the need for an on-site water supply or design factors are discussed as well. Sample problems are included to assist the user.

INTRODUCTION

The Office of the Fire Marshal, in cooperation with the Ministry of Municipal Affairs and Housing and the Water Supply Adequacy Committee has developed this guideline to help building owners, consultants and others involved in life safety design of buildings, meet the requirements for **"adequate water supply for fire fighting"** as found in Part 3 of the Ontario Building Code (OBC). This guideline is not intended for farm buildings or buildings that fall within Part 9 of the OBC.

This guideline has been developed in conjunction with the A-3.2.5.7. Appendix Note on Adequate Water Supply in the 1997 Ontario Building Code.

The *primary purpose* of this guideline is to provide an adequate fire protection water supply to support evacuation and fire department search and rescue operations during a fire, and prevent fire spread to other buildings.

The *secondary purpose* of this guideline is to provide a fire protection water supply that can be used to provide a good measure of property protection during the early stages of a fire.

With the exception of sprinklered buildings, this guideline does not intend to provide the optimum for property protection. However with a timely response by a well trained fire department, the water supply designated in this guideline should be sufficient to allow the fire department to extinguish building fires where adverse circumstances are not encountered.

It should be noted that where "property protection" is a primary expectation of the building owner, or where significant environmental contamination from a fire is a concern, other recognized fire protection guidelines should be referenced (such as the Fire Underwriters Survey) to ensure adequate water supplies for manual fire suppression by available fire fighting means, or the building should be sprinklered. **Building owners should be made aware of the limitations of the fire protection water supply as required in this guideline, prior to the design and construction of their building and/or the design of an on-site water supply.**

It should be noted that other guidelines, such as the Fire Underwriters Survey, should be used when designing water supply systems for newly developed municipal areas, as this fire protection water supply guideline is not intended to address domestic service water needs.

OVERVIEW OF THE BUILDING CODE REQUIREMENTS

Article 3.2.5.7. of the Ontario Building Code (OBC) 1997 states: "an adequate water supply for fire fighting shall be provided for every building".

Q1 What does this mean for unsprinklered buildings?

As interpreted in this guideline, an adequate fire protection water supply for unsprinklered buildings means an immediately available and accessible water supply, with sufficient volume and/or flow to enable the fire department to use their fire hoses to control fire growth until the building is safely evacuated and search and rescue operations have been complete, and to prevent the fire from spreading to adjacent buildings. This water supply should also be sufficient to provide a limited measure of both property protection and protection against fire growth in buildings with contents that could result in a significant environmental impact.

Q2 What does this mean for sprinklered buildings?

For sprinklered buildings, an adequate fire protection water supply means a reliable water supply providing sufficient water flow for the sprinkler systems in terms of pressure, volume, and duration to limit fire growth until the fire department arrives to suppress the fire. This automatic protection is expected to provide time for the evacuation of buildings, assist the fire department in preventing fire spread to adjacent buildings, limit the environmental impact of fires, and provide significant property protection.

Note: A properly designed sprinkler system, and especially those using modern technology sprinkler heads, will often extinguish a fire even without additional manual fire fighting intervention.

FIRE DEPARTMENT RESPONSE

Q1 How does fire department response influence water supply requirements?

Determining an adequate water supply for manual fire protection is not dependent solely on building characteristics. A major factor will be the response time and intervention provided by the local fire department. This guideline assumes a prompt response by a well equipped fire department using modern fire fighting techniques, and assumes that buildings will be evacuated in accordance with established building fire safety plans and fire department pre-fire plans. Where there is no fire department see Q3 in the Special Cases Section.

An immediately available fire protection water supply permits the fire department, at their discretion, to enter a burning building with hose lines to conduct search and rescue operations. The duration of this water supply should, as a minimum, be sufficient to allow complete search and rescue throughout buildings. Once the search and rescue operations are complete, additional water may be required for exposure protection or for fire suppression to limit property damage. Exposure protection and fire suppression to limit property damage go beyond the minimum for life safety as established by water supply requirements set out in this guideline.

The fire department has discretion as to how they will use hose streams on any given fire. Where a limited amount of fire protection water is available on site, decisions will be made on how much water will be used in the initial "search and rescue" stage, the suppression stage and for exposure protection. The Fire Chief may deem it most beneficial to concentrate all fire department resources to suppress a fire in its early growth stage, thereby drawing-down the limited water supply quickly, or may instead "nurse" the limited water supply until the search

and rescue procedure is completed and then concentrate on exposure protection until supplemental water supplies arrive.

Fire departments serving remote or rural areas often have to respond to a fire with a transportable water supply having a duration of approximately five to ten minutes when using one or two 38 mm hose lines. This provides minimal hose streams allowing immediate search and rescue and fire suppression in small buildings with simple layouts. However, where a fire has had a significant head start, this transported water supply is unlikely to be sufficient to save the building.

For larger, more complex buildings, an on-site fire protection water supply is needed to provide an extended duration of hose stream use by the fire department to allow search and rescue of the building, exposure protection and fire suppression. The volume of this on-site fire protection water supply is dependent on the building size, construction, occupancy, exposure and environmental impact potential, and shall be sufficient to allow at least 30-minutes of fire department hose stream use.

COST IMPACT

Q1 **How significant a cost impact will it be to provide an adequate fire water supply?**

Cost impact on buildings constructed in rural or remote areas will typically be more than for buildings constructed within areas provided with municipal water mains. The great majority of existing municipal water systems will be able to satisfy the requirements of this guideline for new building construction. This would not preclude situations where new large "high fire demand" type buildings are being proposed in areas where the municipal water supply is not adequate. In these cases the building owner may need to provide supplemental fire protection water to meet the requirements of this guideline. The building owner may alternatively make design modifications to his building to reduce the water supply requirements. These modifications could include providing firewalls, using noncombustible construction in lieu of combustible construction, sprinklering the building, reducing the amount of window openings exposing a property line, etc.

Buildings constructed in rural or remote areas without a municipal water supply or an adjacent accessible body of water (i.e. river or large pond) may require on-site water storage tanks or a water reservoir for the fire protection water supply required by this guideline. Hydrants, suction connections for fire department "drafting", or underground dry mains may also be needed to provide appropriate building coverage. (See Q7 in the Special Cases Section)

SIGNIFICANT ADVERSE ENVIRONMENTAL IMPACT

Q1 **What types of building fires could result in a significant adverse environmental impact and thus require additional fire protection water supplies?**

Any building used for the storage or processing of chemicals or materials should be deemed to have the potential for significant adverse environmental impact, if a fully developed fire would result in significant contamination of ground or surface water through direct runoff or atmospheric dispersion.

Q2 What fire protection criteria should be used for these buildings?

Properly designed sprinkler protection should be provided in these buildings to prevent fully developed fires. Sprinklered buildings typically require reduced amounts of water for control or suppression of a fire, thus reducing the potential for environmental impact from contaminated water run-off.

Where sprinkler protection is not provided, other recognized fire protection guidelines (e.g. Fire Underwriters Survey) may instead be used to determine the manual fire fighting water supply needs for these buildings. The Chief Building Official or Fire Official should evaluate these special cases on an individual basis.

Q3 Why do unsprinklered buildings with occupancies that constitute an adverse environmental impact typically require an increased water supply for manual fire fighting?

An increased water supply gives the fire department the option of conducting an all out fire hose suppression attack in the early stages of a fire. A successful hose deluge attack at this time may result in extinguishment before significant amounts of environmentally hazardous chemicals and materials are involved.
Note: Unsprinklered buildings will require careful preplanning by fire departments to ensure judicious application of this greater amount of fire fighting water to prevent significant adverse environmental impact due to water run-off.

WATER SUPPLY REQUIREMENTS

Q1 How do I determine water supply requirements?

To simplify this guide, requirements have been placed into four categories. It is best to use a process of elimination to determine the correct category of water supply requirements. This guideline is not intended to be used for farm buildings or Part 9 buildings. (see Q8 in the Special Cases Section)

The four categories are:

- buildings not requiring on-site fire protection water supply
- sprinklered buildings
- buildings requiring on-site fire protection water supply
- additions to existing buildings

1. Buildings Not Requiring On-Site Fire Protection Water Supply

(a) A building would not require an on-site water supply for fire fighting if the building satisfies the criteria set out in Item 1(b) or Item 1(c), provided that:

(i) the building is serviced by a municipal water supply system that satisfies Item 3(b), or

(ii) the fire department can respond with a transportable water supply of sufficient quantity to allow them to conduct an effective search and rescue of the building, determined on the basis of other guidelines or standards (such as NFPA 1231, "Standard on Water Supplies for Suburban and Rural Fire Fighting"). (also see Q1 to Q3 in the Special Cases Section)

(b) A building does not require an on-site water supply for fire fighting where all the following criteria are met

(ii) the building height is 2 stories or less,
(iii) the building does not have a Group B occupancy (care or detention),
(iv) the building does not require a sprinkler system or a standpipe and hose system,
(v) the limiting distance from the property line is at least 13 metres if the building has an F-1 occupancy (high hazard industrial), and
(vi) the building constitutes no significant environmental contamination potential under fire conditions.

(c) A building that exceeds 200 m^2 in building area or 2 storeys in building height may not require an on-site water supply for fire fighting where it has an F-3 occupancy with an insignificant combustible loading (such as found in cement plants, steel stock storage sheds, etc.), as determined by the Chief Building Official.

2. Sprinklered Buildings

For sprinklered buildings, NFPA 13, "Standard for the Installation of Sprinkler Systems", as referenced by Article 3.2.5.13. of the Ontario Building Code, shall be used to obtain sprinkler and hosestream water requirements. (see Q1 of the Further Explanation of Guideline Requirements Section)

3. Buildings Requiring On-Site Fire Protection Water Supply

(a) Except for sprinklered buildings and as required by Items 3(c) and 3(d), new buildings shall be provided with a supply of water available for fire fighting purposes not less than the quantity derived from the following formula:

$$Q = KVS_{Tot}$$

where
Q = minimum supply of water in litres
K = water supply coefficient from Table 1
V = total building volume in cubic metres
S_{Tot} = total of spatial coefficient values from property line exposures on all sides, as obtained from the formula:

$$S_{Tot} = 1.0 + [(S_{Side1}) + (S_{Side2}) + (S_{Side3}) + \text{... etc.}]$$

where S_{Side} values are obtained from Figure 1, as modified by Items 3(e) and (f), and
S_{Tot} need not exceed 2.0

(see Explaining the Calculations Section)

(b) Except as provided in Item 3(d), water supply flow rates shall not be less than that specified in Table 2. Where the water supply is from a municipal or industrial water supply system then the required flow rate shall be available at a minimum pressure of 140 kPa

(c) Except as provided in Item 3(d), the minimum fire protection water supply (Q) required in Item 3(a) shall not be less than what is needed to provide the minimum flow rate specified in Table 2 for a duration of **30 minutes**.

(d) In elementary and secondary schools, the water supply determined in accordance with Items 3(a) and 3(b) may be reduced. The level of reduction to be applied would be at the discretion of the local jurisdictional authority, and should not exceed 30%. Factors to consider should include fire department response time, fire department resources and the size and complexity of the school building. (see Q10 of the Special Cases Section)

(e) Where a masonry wall with a minimum fire-resistance rating of 2 hr. and no unprotected openings is provided as an exterior wall, the spatial coefficient (S_{side}) for this side of the new building may be considered equal to 0. This exterior masonry wall shall be provided with a minimum 150 mm parapet.

Firewalls that divide a structure into two or more buildings may be given similar consideration when evaluating the exposure of the buildings to each other.

(f) The spatial coefficient (S_{side}) may be considered equal to 0 when the exposed building is on the same property and is less than $10m^2$ in building area.

4. Additions to Existing Buildings

(a) Except as permitted in Items 4(b) and (c), additions to existing buildings shall be provided with a fire protection water supply as required in Items 3(a) to 3(f). (See Q2 in the Further Explanation of Guideline Requirements Section)

(b) Buildings with new additions falling into any one of the following criteria would not require an additional water supply for fire fighting where:

(i) the expanded building complies with all the requirements of Item 1(a),

(ii) the new addition does not exceed $100m^2$ in building area, or

(iii) the new addition exceeds $100m^2$ but does not exceed $400m^2$ in building area, contains an assembly, business and personal services, mercantile or low hazard industrial occupancy, is of noncombustible construction, does not result in a significant increase in exposure to other existing buildings, has no combustible storage or process, and is separated from the existing building by a minimum 1 hour fire-rated separation.

(c) Where a firewall is provided between the new addition and the existing building, the fire protection water supply may be determined in accordance with Items 1(a) and 3(a), using only the building volume of the new addition.

Note: Consideration should be given to designing the water supply to the more stringent requirements of the two separated buildings.

TABLE 1
WATER SUPPLY COEFFICIENT – K

TYPE OF CONSTRUCTION	Classification by Group or Division in Accordance with Table 3.1.2.1 of the Ontario Building Code				
	A-2 B-1 B-2 B-3 C D	A-4 F-3	A-1 A-3	E F-2	F-1
Building is of noncombustible construction with fire separations and fire-resistance ratings provided in accordance with Subsection 3.2.2. of the OBC, including loadbearing walls, columns and arches.	10	12	14	17	23
Building is of noncombustible construction or of heavy timber construction conforming to Article 3.1.4.6. of the OBC. Floor assemblies are fire separations but with no fire-resistance rating. Roof assemblies, mezzanines, loadbearing walls, columns and arches do not have a fire-resistance rating.	16	19	22	27	37
Building is of combustible construction with fire separations and fire-resistance ratings provided in accordance with Subsection 3.2.2. of the OBC, including loadbearing walls, columns and arches. Noncombustible construction may be used in lieu of fire-resistance rating where permitted in Subsection 3.2.2.	18	22	25	31	41
Building is of combustible construction. Floor assemblies are fire separations but with no fire-resistance rating. Roof assemblies, mezzanines, loadbearing walls, columns and arches do not have a fire-resistance rating.	23	28	32	39	53
Column 1	2	3	4	5	6

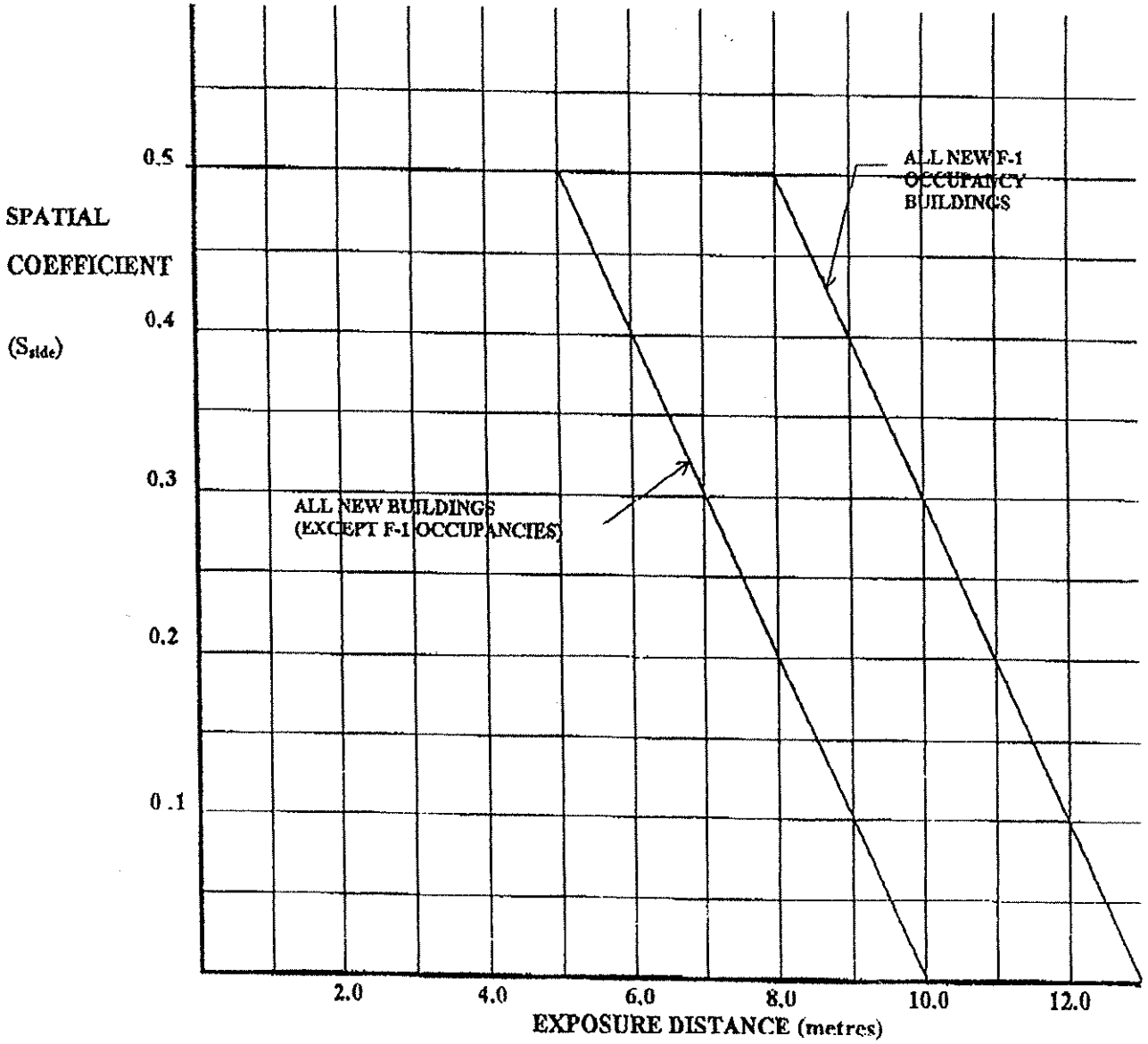
TABLE 2
MINIMUM WATER SUPPLY FLOW RATES

OBC Part 3 Buildings	Required Minimum Water Supply Flow Rate (L/Min.)
One-storey building with building area not exceeding 600m² (excluding F-1 occupancies)	1800
All other buildings	2700 (If Q ≤ 108,000L)[1] 3600 (If Q > 108,000L and ≤ 135,000L)[1] 4500 (If Q > 135,000L and ≤ 162,000L)[1] 5400 (If Q > 162,000L and ≤ 190,000L)[1] 6300 (If Q > 190,000L and ≤ 270,000L)[1] 9000 (If Q > 270,000L)[1]

Note [1] $Q=KVS_{tot}$ as referenced in Item 3(3)

FIGURE 1

SPATIAL COEFFICIENT VS EXPOSURE DISTANCE



EXPLAINING THE CALCULATIONS

Q1 What is the "K" factor and how were these values developed?

The K factor, also known as water supply coefficient, is a value that takes into account typical compartmentalization of buildings, combustibility of construction, combustible loading of the building occupancy and evacuation responses by the building occupants.

These factors were developed using the "occupancy hazard classification numbers" and "construction classification numbers" in NFPA 1231, adjusting them to fall within the occupancy classifications of buildings within the Ontario Building Code, and then modifying them so that the final units of the equation are in litres. Table 1 of this guideline lists K values according to type of construction and occupancy classification.

Q2 What volume is included in "V"?

All spaces below and above grade within a building, measured to the underside of the roof deck, should be included in the volume (cubic metres) for the fire protection water supply formula. An exception may be made to exclude a non-combustible crawl space (with no combustible services) below a non-combustible floor, located under the lowest building floor area, if it will not be developed in the future or used as a storage area.

Q3 How are "exposures" measured?

Exposure distances from a new building will be measured from the exterior building faces to the property lines of that building. The distance from the face of the building to the property line shall be determined as per OBC 3.2.3.1.(3). When facing a street, the property line shall be deemed to be the centre of the street.

When facing an existing building (exceeding 10 m² in building area) on the same property, the exposure distance (for use in Figure 1) shall be the greater of either the "limiting distance" of the new building face as obtained in OBC 3.2.3.1.(1), or the mid-point between the two buildings.

Q4 How are spatial coefficient values obtained from Figure 1?

Once the exposure distance for each building face has been determined, these values can be located along the horizontal arm at the bottom of Figure 1. By following straight up from these points the graph line may be intersected providing a spatial coefficient value (S_{side}) along the left vertical arm of Figure 1. Exposure distance values of at least 10 m. (except F-1 occupancies which require a minimum of 13.0 m) result in a spatial coefficient value of 0.

Q5 How are multiple exposures calculated?

Where a new building has exposures on more than one side, the percentage increase in the fire protection water supply due to the exposures on each side should be totaled to reflect all exposure protection requirements. [e.g. if exposure to one side results in a 50% increase in water volume (i.e. $S_{side1} = 0.50$), and exposure to another side results in a 25% increase in water volume (i.e. $S_{side2} = 0.25$), then the total increase in water volume for exposure protection is 75%. The totaled spatial coefficient (S_{tot}) is then

Q6 What is the rationale for the minimum 30 minute water supply duration and what new buildings will be most affected by this requirement?

The minimum 30 minute fire protection water supply duration requirements as stated in Item 3(b), recognizes life safety concerns by providing a dependable and immediately available fire protection water supply for the fire department's use. It is intended that the duration be long enough to allow complete search and rescue of any building by the fire department. This minimum fire protection water supply should also give the fire department a reasonable opportunity to control and/or extinguish a small fire upon their arrival, thereby preventing its growth and spread to adjacent buildings and limit any negative environmental impact. This minimum 30 minute duration requirement also allows a reasonable time for the fire department to arrange for supplementary water supplies using a water shuttle system for most buildings.

Concerns for minimum fire protection water supply volumes are mostly relevant for building sites not serviced by municipal water supply systems, where an on-site fire protection water supply has to be provided. Building sites serviced by municipal water supply systems will usually be provided with sufficient water volumes for their fire protection needs. The guideline focuses on water supply flow rates at minimum pressures for these buildings. It should be noted however that some municipalities have fairly limited water supply storage capacities and should therefore be evaluated when a new "high demand" building is to be constructed.

Q7 How do exterior 2 hr. rated masonry walls with parapets and no unprotected openings and interior firewalls influence exposure, and thus water supply calculations?

Interior firewalls and exterior masonry walls fire-rated for 2 hours, with parapets and no unprotected openings, are expected to remain in place during the period that fire exposure is greatest. Exposure to adjacent buildings is reduced to a point where additional exposure protection water may not be needed.

Judgment by the Chief Building Official should be used in determining the design of exterior 2 hour fire-rated masonry walls and interior firewalls with regard to exposures. The usual 6 inch parapet may not be considered adequate exposure protection where a new building exposes a much higher existing building in close proximity. Rather than having to increase the water supply due to exposure, a higher parapet may be sufficient protection. In situations where parapet design or other exposure protection methods do not provide adequate exposure protection for the existing building, then additional exposure fire protection water may be required.

Where firewalls divide a new facility into separate buildings, the fire protection water supply should be sized to the building with the greatest water supply demand.

Q8 What would be the impact on fire protection water supply requirements for a new building if an existing exposed property has its own on-site fire protection water supply?

Where a new building exposes an existing property provided with its own independent on-site fire protection water supply, the Chief Fire Official may deduct this water supply from the quantity needed by the new building due to this exposure. This neighbouring water supply should be accessible to the fire department to protect exposed buildings.

The Chief Fire Official should be satisfied that the two property owners will properly maintain their respective fire protection water supplies for the life of their buildings. This agreement may require approval from the municipality and may be subject to criteria provided by the Building Code Commission.

FURTHER EXPLANATION OF GUIDELINE REQUIREMENTS

Q1 Regarding sprinklered buildings, where in NFPA 13 are hose stream requirements specified?

NFPA 13 contains the hose stream requirement for sprinklered buildings in the "Occupancy Hazard Fire Control Approach" section (in Chapter 5 of 1992 to 1998 NFPA 13 edition). Within, is a table entitled "Hose Stream Demand and Water Supply Duration Requirements". This table provides total inside and outside hosestream requirements and duration for each hazard classification of sprinkler system design.

A sprinkler contractor designing a sprinkler system for a building will determine the minimum water supply requirements for the sprinkler system. Using the duration period obtained from the above referenced table, the contractor will add the sprinkler and hose stream requirements and calculate the total fire protection water supply required for the building.

Q2 Where new additions are added to existing buildings that do not have an on-site water supply, what volumes of water are considered adequate for life safety and exposure?

Whereas Part 11 of the OBC indicates that only the addition to an existing building is required to conform to OBC Part 3, this might in reality not be adequate to deal with life safety and exposure where fire protection water supply needs are concerned.

When an addition is added to an existing building and water supply calculations are based only on the volume of the addition, the fire protection water supply provided on-site might not be adequate to allow full search and rescue throughout the entire building. As well, exposure to neighbouring buildings from the new addition may not be reflective of the nature and size of a potential fire in the enlarged building. Calculations using the entire volume of an expanded building therefore are the only accurate indication of fire protection water supply needs.

Q3 Does this guideline apply to buildings that are being renovated under Part 11 of the Building Code?

Part 11 of the Building Code should be reviewed to determine the conditions under which Article 3.2.5.7. applies. This is found in the Compliance Alternative tables in Part 11.

Where Article 3.2.5.7. does apply, the existing water supply should be evaluated to determine if it is sufficient for the renovated building. Some discretion may be used by the building official if the water supply for the renovated building is not significantly greater than the existing water supply.

SPECIAL CASES

Q1 Can water transported by the fire department be satisfactory to protect small buildings?

Smaller buildings of 2 stories or less and with a building area of 200m^2 or less, may be adequately protected by a fire department using proper pre-planning methods and transported fire protection water supplies. NFPA 1231, "Standard on Water Supplies for Suburban and Rural Fire Fighting", provides methods to assist the fire department with this pre-planning. Where the fire department does not have the equipment necessary for a proper water shuttle system to adequately protect these smaller buildings as per NFPA 1231, an on-site fire protection water supply should be considered.

Q2 What extra precautions, if any, should be taken for institutional occupancies?

Buildings with Group B, Division 1, 2 and 3 occupancies should be treated in a special manner with respect to fire protection water supplies. The occupants of these buildings require direct supervisory assistance for phased evacuation during a fire. This could result in a prolonged search and rescue by the fire department. If this type of building is located in areas not serviced by municipal water mains, the fire protection water supply that the fire department is capable of transporting to the site may not be adequate for the duration of this search and rescue period. Only a properly sized on-site fire protection water supply will provide the hose stream duration that the fire department needs. Alternatively, sprinkler protection could be provided.

Q3 What provisions should be made where fire department response is slow or nonexistent?

For new buildings constructed in areas where fire department response is not expected in a reasonable time, the building should be sprinklered to help ensure safe evacuation. In locations where a fire department pumper truck is not provided, consideration should be given to installing a private water supply capable of providing a minimum 700 kPa (100 psi) water pressure at the required flow rate to permit fire fighters or other persons trained in the use of fire hoses, to effectively use a "fog-nozzle" hose spray on the fire. This type of hose spray is most effective at controlling fires. Alternatively, sprinkler protection could be provided.

Q4 How should an outdoor reservoir be designed to take into account ice formation?

When designing an open, unheated reservoir to provide a fire protection water supply as required in this guideline, a 600 mm ice depth allowance should be included in the water volume calculations. Where local winter temperature conditions result in a greater ice depth (as typically found on local lakes or ponds), this should be factored into the volume calculations.

Q5 What provisions should be made to ensure that water reservoir supplies do not drop to unsafe levels as a result of evaporation or leakage?

A make-up water supply should be provided to maintain the design volume of fire protection water supply reservoirs. Storage tanks should be provided with limit switches, pressure gauges or water-level gauges to monitor volume.

If make-up water supply for open water supply reservoirs is provided by natural refill methods (i.e water table seepage) and periods of drought are common, the reservoir capacity should be increased to take into account the reduced water table levels expected from the evaporation of water.

Q6 What standards should be used to provide an acceptable water supply design?

Tanks should conform to NFPA 22, "Water Tanks for Private Fire Protection", and the local fire department should be consulted to determine appropriate connections for their pumping equipment.

Fire main installations should conform to NFPA 24, "Private Fire Service Mains and Their Appurtenances".

On-site fire pump installations should conform to NFPA 20, "Standard for the Installation of Centrifugal Fire Pumps".

Sprinkler standards other than NFPA 13, "Standard for the Installation of Sprinkler Systems", such as NFPA 13D, "Installation of Sprinkler Systems in One- and Two-Family Dwellings and Mobile Homes", and NFPA 13R, "Installation of Sprinkler Systems in Residential Occupancies Up To and Including Four Stories", may be used where appropriate for the type of building covered by these standards. These other standards should be acceptable to the local jurisdictional authority.

For new buildings that present a special hazard to a community as a result of their size, occupancy or economic importance, the Fire Underwriters Survey Guide should be used to determine suitable water supply and hydrant siting.

Q7 For evaluation of the fire protection water supply and associated fire hydrants, are there other considerations in addition to those set out in the OBC?

Impounded fire protection water supply for a remote building shall be accessible to the fire department to allow the use of suction lines for drafting either directly from the impounded water source, or from a dry hydrant supplied from the impounded water source. This water source or hydrant shall be located in adherence to OBC 3.2.5.7.(2).

Where at least two widely separated private fire hydrants are required to protect a building and water is to be supplied from a single on-site fire protection water supply (e.g. reservoir), it is acceptable to provide a fire department pumper connection adjacent to the water supply to allow a pumper truck to pump into an underground "dry" main feeding the two remote hydrants. This arrangement permits fire fighters to attach hoses directly to the hydrants or to use a second pumper truck to draw boosted water from these hydrants.

Existing water flow test information obtained to determine the adequacy of the municipal or private water supply for fire protection of a new building should be evaluated with regard to how dated the test information is, whether the flow test was conducted during high or low demand periods, and the possibility that future development in the area will significantly affect the supply. A current hydrant flow test at the proposed construction site will provide the most accurate information.

When dealing with new buildings serviced by municipal or industrial pressurized fire protection water systems, this guideline specifies a minimum water flow rate at 140 kPa pressure. The 140 kPa pressure is the accepted minimum that most fire departments will allow service mains to be drawn down to. Water main and/or booster pump damage could occur from cavitation at pressures below this level.

Q8 Can this guideline be used for Part 9 of the OBC?

The OBC does not currently require that Part 9 buildings be provided with an adequate water supply for fire fighting. However, this guideline may be used on a voluntary basis to provide a suitable fire protection water supply for these buildings.

The Water Supply Adequacy Committee recommends that an on-site fire protection water supply as required by this guideline be provided for multi-unit residential (Group C) type buildings (i.e. hotels, motels, apartments, townhouse complexes, etc.) that fall within Part 9 of the OBC. These buildings inherently have delayed building evacuation, resulting in more extensive search and rescue operations, and will likely benefit from an on-site fire protection water supply.

Q9 How are standpipes and hose systems affected by these requirements?

Where a building requires a standpipe and hose system per the OBC, the standpipe system should continue to be designed to Article 3.2.9.2. The standpipe will draw from the required water supply specified in this guideline, still leaving a significant fire protection water supply for exterior hose stream use.

Q10 Can the water supply requirements of this guideline be reduced in buildings with an established fire safety plan that can ensure a rapid building evacuation?

Elementary and secondary schools have a record of well established and practiced fire safety plans which allow complete school evacuations within 4 minutes. Because of this and the inherent high level of supervision in these types of facilities, a reduction of up to 30% in the fire protection water supply requirements as set out for unsprinklered buildings in this guideline may be given. However, caution should be used if the duration of water supply is reduced to less than 30 minute, unless other compensating features are also provided.

Other considerations to keep in mind should include disabled students and teachers that are being introduced into the general school population. A delayed evacuation may be expected for them. This could result in prolonged search and rescue operations by the fire department and should be considered when determining water supply reductions.

Q11 Can the water supply requirements of this guideline be reduced if alternate fire suppression methods are proposed?

Alternate fire suppression methods may result in reduced water supply requirements when compared to design parameters set out in this guideline. Questions should be directed to the local authority that has jurisdiction over these matters.

Alternative fire suppression methods being considered for allowing a reduction in the water supply requirements of this guideline are, foam/water extinguishing systems, carbon dioxide extinguishing systems or dry chemical extinguishing systems. Exterior water curtain (deluge) systems may be considered in lieu of fire protection water supply requirements for exposure purposes.

WATER SUPPLY ADEQUACY COMMITTEE

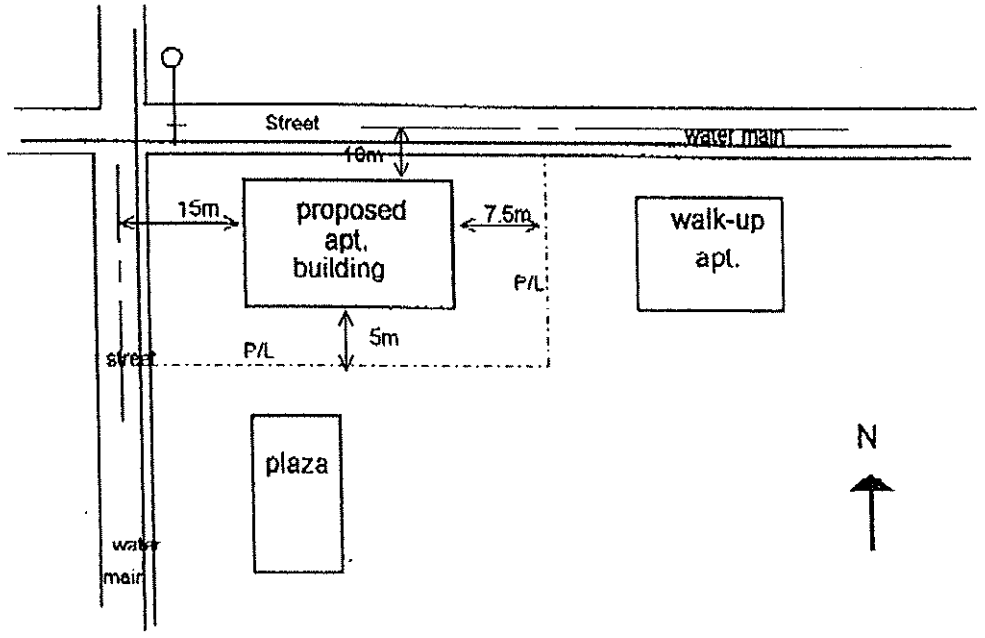
Kim Bailey - Office of the Fire Marshal
John Braun - American Water Works Association
Roy Chalk - Ontario Municipal Fire Prevention Officers Association
Steve Penna - Ontario Building Officials Association
David Shantz - Municipal Engineers Association
Tom Eyre - Ontario Municipal Water Association
Don Livingston - Ministry of Housing, Buildings Branch
Ed Coe - Insurers Advisory Organization
Chief Tom Powell - Ontario Association of Fire Chiefs

EXAMPLE PROBLEMS

PROBLEM #1

A new apartment building is to be constructed in your municipality. The building will measure 30m by 25m, with 3m between floors, and consists of 3 storeys plus a basement used for storage and laundry facilities. Parking will be outside. The building is to be of combustible construction and is to conform to 1997 OBC 3.2.2.47. An attic space is also provided in this building with a 750m^3 volume. A 30 min. fire separation is provided between the 3rd floor and the attic space. The building is not to be sprinklered nor provided with a standpipe system.

The building is located on a corner lot and faces 2 streets (see diagram). Property lines are located 5m to the south and 7.5m to the east of the proposed building. All of the buildings are serviced by municipal water mains and hydrants. What is the required minimum flow rate of the municipal main for an adequate fire protection water supply?



SOLUTION - PROBLEM #1

(1) Determine building classification

-residential apartment is Group C

(2) Check parameters of Item 1(a) to determine whether building requires an on-site water supply. *- building exceeds 200m², has two stories with significant combustibles and is not a Part 9 building, therefore needs water supply evaluation*

(3) Calculate $Q=KVS_{Tot}$

(i) determine K

- from Table 1, based on building construction and classification, the water supply coefficient K=18

(ii) calculate the building volume, $V= L \times W \times H$

- use total height of building, 3 storeys plus basement, and attic space (750m³).
(3m between floors x 4 floors =12m)
$V=$ (30m x 25m x 12m) + 750m³ = 9750m³

(iii) Determine S_{Tot} from Figure 1

- consider each side of the building:
- the north and west sides of the building each face a street and the distance to the centre of the streets exceed 10m, so S_{Side} will be equal to 0.0 on both sides.
- the property line is 5m to the south of the building. From Fig. 1, S_{Side} is equal to 0.5, meaning that a 50% increase in the volume of water will be required to protect this side.
- the property line to the east of the building is 7.5m. From Fig. 1, S_{Side} is equal to 0.25, meaning that a 25% increase in the volume of water will be required to protect this side.
-therefore, because of the exposure on the south and east sides of the building, it will be necessary to increase the total volume of the water by 75% (the sum of all the spatial coefficients from each side).

i.e. S_{Tot} = 1+ (total of spatial coefficients)
= 1+ (0.5 + 0.25)
= 1.75 (Note: S_{Tot} need not exceed 2.0)

therefore, $Q = KVS_{Tot}$
$= 18 \times 9750 \times 1.75$
$= 307,125$ litres

(4) determine the water supply flow rate

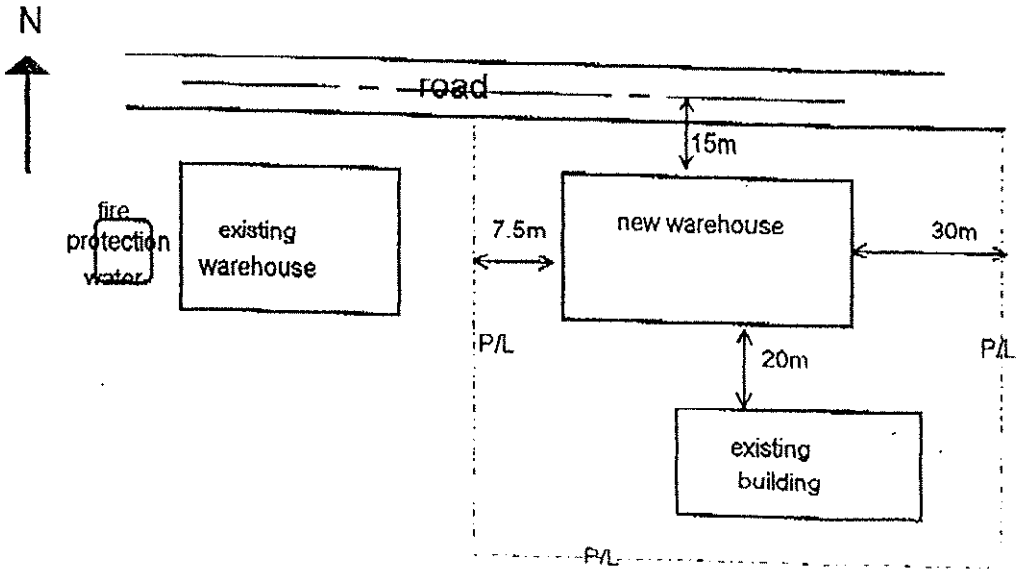
- from Table 2, since the building either exceeds 1 storey or its area is greater than 600 m², and the calculated Q is greater than 270,000 litres, the required minimum water supply flow rate from the municipal system would be 9000 L/Min.
- this flow rate is required at 140 kPa in accordance with Item 3(b).

PROBLEM #2

A single storey warehouse and distribution center, classified as a low industrial hazard occupancy, is to be built in an area not serviced by a municipal water supply. The building is to be 1500 m² in area, 4 metres high and of noncombustible construction conforming to Subsection 3.1.5. of the Ontario Building Code. This building falls within 1997 OBC 3.2.2.80. Storage commodities vary, but in general are farm implements in wood crates.

The warehouse faces one street to the north, with property lines 30m to the east and 7.5m to the west. An existing building is located on the same property and will be 20m to the south of the proposed new warehouse. The new warehouse building will have 10% unprotected openings in its south face.

There is a similar type warehouse that has its own 20,000 litre on-site fire protection water supply located to the west. This water supply is determined by the fire department to be reliable and accessible. How much water will be required on site for fire protection of the proposed building?



SOLUTION - PROBLEM #2

(1) Determine building classification

proposed low hazard warehouse building is Group F-3

(2) Check parameters of Item 1(a) to determine whether building requires an on-site water supply.

building is a Part 3 building as it exceeds 600 m² in area and has a significant combustible loading, therefore needs on-site water supply

(3) Calculate $Q=KVS_{Tot}$

(i) determine K

- from Table 1, based on building construction and classification the water supply coefficient K=19

(ii) calculate the building volume, V= Area x H

$= (1500 \times 4) = 6000\ m^3$

(iii) Determine S_{Tot} from Figure 1 by considering each side of the building:

- on the east side of the proposed building the distance to the property line exceeds 10 meters so no increase in water volume is necessary.

- the proposed building faces a street on the north side with distance to the center of the street 10 meters away. No increase in the water volume will be required due to lack of exposure on this side.

- the proposed building faces an existing building on the same property, 20m to the south. The 10% unprotected openings in the south building face of the proposed building results in a "limiting distance" of 2.5m using Table 3.2.3.1.A. of the OBC. Since the midpoint between the two buildings on the same property (10m) is greater than the limiting distance of the south face of the new building, the 10m is deemed the exposure distance. No increase in water volume will therefore be needed from exposure on this side.

- the property line to the west is 7.5 meters from the exterior wall, which means a 25% increase in the volume of water to protect the property on that side. However, the neighbour's warehouse has its own reliable 20,000 litre fire protection water supply, so this can be used to reduce the exposure needs. Exposure calculations should be completed to evaluate the neighbouring water supply, therefore,

$S_{Tot} = 1 +$ total of spatial coefficients

$= 1 + (.25) = 1.25$

and, $Q = KVS_{Tot}$

$= 19 \times 6000 \times 1.25 = 142{,}500$ litres

Of this amount, 28,500 litres (142,500 - 114,000 = 28,500) is required for exposure, of which 20,000 litres is already provided on the exposed property. Therefore an additional 8,500 litres should be added to the on-site water supply to make up the shortfall in exposure protection. Therefore, Q= 122,500 litres (114,000 + 8,500 = 122,500).

(4) determine the water supply flow rate

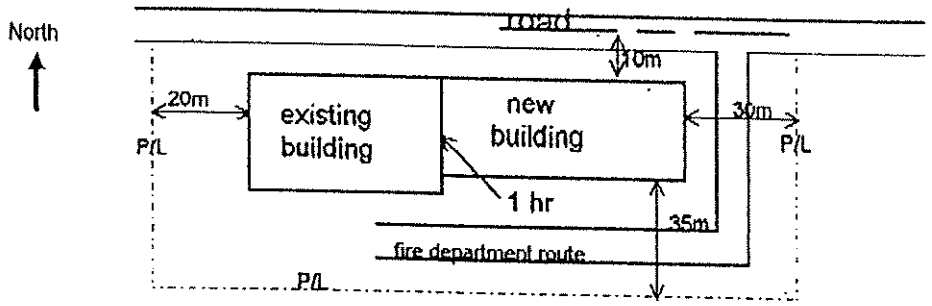
- from Table 2, since the building area exceeds 600m² and the calculated Q is greater than 108,000 litres but less than 135,000 litres, the required minimum water supply flow is 3600 L/Min. However, in accordance with Item 3(b) it must also be confirmed that 3600 L/Min. can be flowed for a minimum 30 minutes. Since a 34 min. duration is achieved (122,500 ÷ 3600 = 34 min.), this is satisfactory.

PROBLEM #3

An existing 400 m² single storey (with basement) school is being provided with a 400 m² addition of noncombustible construction. The existing building is of combustible construction with a 45 min. rated roof and basement ceiling (structural supports rated as well), while the new addition is of noncombustible construction as well and meets the requirements of 1997 OBC 3.2.2.25. Both the new and existing buildings are provided with full basements, 2.5 m. in height. The ground floor has a ceiling height of 3.0 m. An attic space is provided in both buildings, each with volume of 800 m³. A 1 hr. fire rated separation is to be provided between the new and existing structures.

No water mains or hydrants are located in the area. A hose standpipe is voluntarily being provided throughout the entire building, with a booster pump. Distances to the property lines are as indicated on the accompanying sketch. An all volunteer fire department with limited equipment is located within 20 min. of the building site.

What size pond is needed on site (assuming no freezing temperatures), to ensure minimum life safety requirements?



SOLUTION - PROBLEM #3

(1) Determine building classification
- school building is Group A-2

(2) Go to Item 4(a) of the water supply guideline. Item 4(b)(iii) indicates that a single storey, noncombustible addition with an assembly occupancy, up to 400m² in building area, with no combustible storage or process and separated from the existing building by a minimum 1 hr. fire separation would not require additional water supplies for fire fighting purposes.

(3) The local jurisdictional authority however, may also wish to take into consideration the ability of the local fire department to provide an effective water supply shuttle system to this school by using NFPA 1231 as a guide. If equipment is not available to provide effective amounts of water supply, then an on-site water supply may be the best choice. Note that this is what Item 1(a)(ii) is alluding to.

(4) If an on-site water supply is chosen, it may be sized by calculating $Q = KVS_{Tot}$

(i) although OBC Part 11 would only size the on-site water supply to the addition, the fire department should determine if this is sufficient for their search and rescue needs.

(ii) assuming the entire building volume is selected to determine Q, determine K
- from Table 1, based on building construction and classification the water supply the existing building has a coefficient K=18 and the new addition has a coefficient K=16.

(iii) calculate the building volume, V=L x W x H
$V_{Existing} = (400 \times 3) + (400 \times 2.5) \div 800 = 3000\ m^3$
$V_{Addition} = (400 \times 3) + (400 \times 2.5) \div 800 = 3000\ m^3$

(iv) Determine S_{Tot}
- From Figure 1, since no property lines are less than 10 m away, all Ssides = 0.0, therefore no addition water volume is needed for exposures. ∴ $S_{Tot}=1.0$

$Q = KVS_{Tot}$
$= (KVS_{Tot})_{Existing} + (KVS_{Tot})_{Addition}$
$= (3000 \times 18 \times 1.0) + (3000 \times 16 \times 1.0)$
$= 102{,}000$ litres

This is the required pond size, assuming a means to maintain the water level and no freezing concerns. Note that Item 3(d) also allows a reduction in the water supply and flow rate for schools. This reduction may not be considered due to the all volunteer fire department with limited equipment.

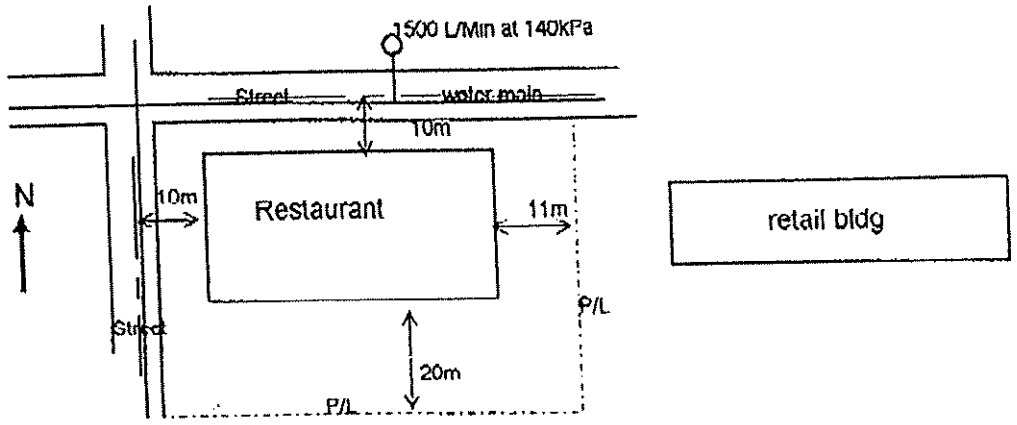
(5) determine the water flow rate
- from Table 2, since the building area exceeds 600m² and the calculated Q is less than 108,000 litres, the required minimum water supply flow is 2700 L/Min. However, in accordance with Item 3(b) it must also be confirmed that 2700 L/Min. can be flowed for a minimum 30 minutes. Since a 38 min. duration is achieved (102,000 ÷ 2700 = 38), this is satisfactory. Note if the water supply was sized to only the addition then a 54,000 litre pond, allowing a 30 minute duration at a flow rate of 1800 L/Min. would be required. However, at 2700 L/Min., which is a reasonable flow rate for the entire structure, this provides only 20 min. duration.

PROBLEM #4

A 300 m² single storey restaurant is to be constructed of noncombustible construction in a town with a marginal water supply due to old mains and poor gridding. The municipal water reservoir is sized for 1.0 million gallons. The building will have a 3.5 m. high ceiling. No hose standpipe or sprinklers are planned.. Is the existing street supply adequate?

Property lines are located 11m to the east and 20m to the south. Street centre line distances are 10m to the north and west.

The fire department routinely arrives at a fire scene in this part of town with a tanker/pumper truck carrying enough water (4500 litres) for two 38 mm hoses adequate for 5 minutes of discharge. The hydrant at the street can provide 1500 L/Min. at 140kPa.



SOLUTION - PROBLEM #4

(1) Determine building classification

-restaurant building is Group A-2 occupancy.

(2) Check parameters of Item 1(a) to determine whether building requires an on-site water supply.

-building falls within Part 3
-building area is more than 200m² and is not an F-3 occupancy.

(3) Compare existing water supply with required water supply

- as the building is ≤ 600m², the required water supply flow rate from Table 2 for this size building is 1800 L/Min.
-provided public water supply from hydrant at street is 1500 L/Min at 140kPa (adequate volume of supply)
-transported water supply by fire department is 4500 litres.
-the required water supply shortfall from public supply only is (1800 -1500)=300 L/Min. The transported water supply by the fire department will last 15 minutes if used at a flow rate of 300 L/Min (4500/300=15 min.) to make up shortfall from the public supply.

(4) Solutions to make up water supply shortfall

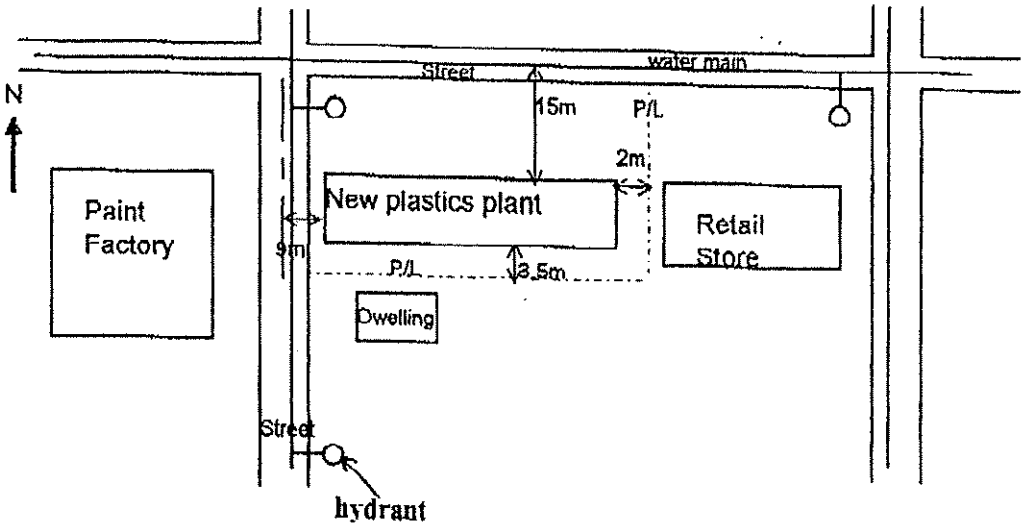
Option #1 - *as the total water supply that is deemed adequate for this new building is 1800L/Min x 30min.= 54000 litres, and the provided water supply is (1500x30)+ 4500 = 49500 litres, then require an additional on-site water supply of 4500 litres*

Option #2 - *provide an additional transportable water supply source (i.e. tanker truck) of 4500 L.*

Option #3 - *the Chief Fire or Building Official may determine that 1650 L/Min is satisfactory based on building occupancy and layout, and the restaurant's fire safety plan. The Chief Fire or Building Official may also determine that "life safety" is no longer a significant concern after 15 minutes in this type of occupancy and the remaining public water supply is satisfactory for exposure concerns.*

PROBLEM #5

A new 4 storey plastics extrusion plant (F-2 occupancy) is being constructed in a town with a marginal water supply. The flat-roofed building will cover a 500 m² area and be 12.0 m. in overall height. Construction is to be combustible and in conformance with 1997 OBC 3.2.2.70. The roof and floor separations have a fire-resistance rating of 45 min. Exposure includes property lines 2m and 3.5m away and street centre lines 9m and 15m away to the west and north. What is the required water supply from the street mains for this new building?



SOLUTION - PROBLEM #5

(1) Determine building classification

-Group F-2 occupancy

(2) Check parameters of Section (1) to determine whether building requires an on-site water supply.

-building is a Part 3 building as it meets dimensional parameters (i.e. more than 3 stories)

(3) Calculate $Q=KVS_{Tot}$

(i) determine K

- from Table 1, based on building construction and classification, the water supply coefficient K=31

(ii) calculate the building volume, $V= L \times W \times H$

$= 500 \times 12$

$= 6000m^3$

(iii) determine S_{Tot} from Figure 1(consider each side of the building) :

- the street center line to the north is more than 10m away thereby providing no exposure concerns.

- the street center line to the west is 9m away thereby resulting in an S_{Side} of 0.1

- the P/L to the east is 2m away resulting in an S_{Side} of 0.5

- the P/L to the south is 3.5m away, resulting in an S_{Side} of 0.5

- therefore the resulting total of spatial coefficient values is:

$S_{Tot} = 1 + (0.1 + 0.5 + 0.5)$

$= 1 + (1.1)$

$= 2.1$

(however as S_{Tot} need not exceed 2.0, assume $S_{Tot} = 2.0$)

(iv) therefore, $Q = KVS_{Tot}$

$= 31 \times 6000 \times 2.0$

$= 372{,}000$ *litres*

-It should be confirmed that the municipal reservoir has this reserve fire fighting water supply capacity.

(4) Determine the water supply flow rate

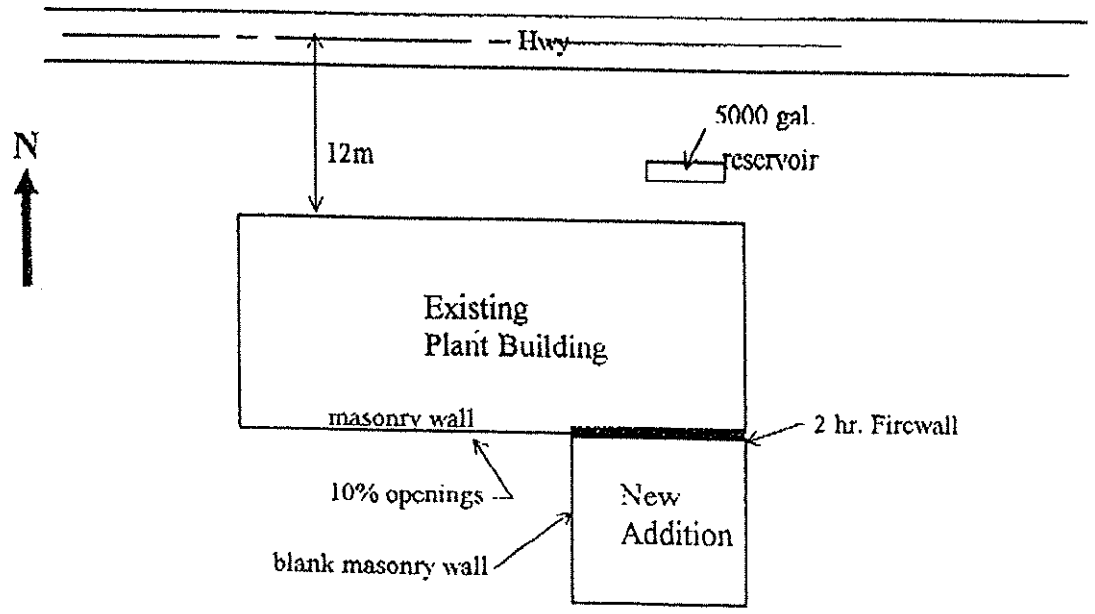
- from Table 2, this type of building requires a minimum fire protection water supply flow rate of 9000 L/Min at 140kPa. Water flow tests on street hydrants at the building site should confirm this minimum flow.

PROBLEM #6

A 200m² single storey flammable liquids storage and paint mixing room is being constructed on the southwest corner of this existing remote 600m², single storey metal parts fabricating and treating plant. The property line is no closer than 60m from the building in the south, east and west directions. The center line of the highway to the north is 12m. An existing 5000 Imp. gal. fire protection water supply is currently provided on-site, with a dry hydrant to provide fire department draft from this reservoir.

The building is located in an area surrounded by agricultural lands used for growing cash crops, and lakes used to provide potable water for the local communities.

The existing building has interior hoses but no sprinklers. The new addition is to be separated from the existing building by a 2 hr. firewall, but is not to be sprinklered. The addition is to be 4m in height and of noncombustible, non-rated construction. The walls of the addition at right-angles to the existing building are blank masonry, while the masonry walls of the existing building at right-angles to the addition has 10% openings. Is the existing water supply sufficient for the addition or the existing building.



SOLUTION - PROBLEM #6:

(1) Determine new building classification

-Group F-1 occupancy

(2) Check parameters of Section (4) for this addition. Item 4(c) deals with firewalls separating additions from existing buildings. Check parameters of Section (1) to determine whether addition requires an on-site water supply.

- the addition has an F-1 occupancy and is therefore a Part 3 building. Because the chemical occupancy of the addition may result in a significant adverse environmental potential to the local aquifer, the addition does not fall within Section 1. Therefore check Section (2) and (3).

(3) Addition is not to be sprinklered so Section (2) does not apply.

(4) From Section (3) calculate Q for the addition using $Q=KVS_{Tot}$

(i) determine K

- from Table 1, based on building construction and classification, the water supply coefficient K=37

(ii) calculate the building volume, $V= L \times W \times H$

$= 200 \times 4$

$= 800m^3$

(iii) determine S_{Tot} from Figure 1(consider each side of the building) :

- the P/L to the east, west and south exceeds 13m resulting in S_{Side} values of 0 in each direction.

- to the north the limiting distance to the south exposed wall of the existing building from the blank west wall of the addition is determined from 1997 OBC 3.2.3.1.(1). Because of the blank masonry wall the limiting distance is 0.

- therefore the resulting total of spatial coefficient values is:

$S_{Tot}= 1+ (0 + 0 + 0 + 0)$

$= 1.0$

(iv) therefore, $Q= KVS_{Tot}$

$= 37 \times 800 \times 1.0$

$= 29,600$ litres

(4) Determine the water supply flow rate

- from Table 2, F-1 occupancy buildings require a minimum fire protection water supply flow rate of 2,700 L/Min. The existing on-site fire protection water supply of 5,000 Imp. gal. (22,750 litres) can provide this flow rate for 8 minutes.

- Since a minimum 30 minute duration in water supply is needed, an additional 58,250 litres of on-site water supply is needed for the addition to make up the shortfall (81,000-22,750).

- The existing building may also be evaluated to see if water supply requirements would be higher. Owner may decide to provide additional water demand if higher.

Note: Under the OBC the existing building also has to be evaluated to determine the

APPENDIX 19

BLACK & McDONALD – HIGH VOLTAGE MAINTENANCE REPORTS DATED AUGUST 1999, REFERENCE NO. 6621

Black & McDonald

Technical Field Service Department

31 Pullman Court, Scarborough, Ontario M1X 1E4. Phone: (416)-298-9977 Fax: (416)-298-2907

August 16, 1999

Toronto Zoo
361A Old Finch Ave.
Scarborough, Ontario
M1B 5K7

ATTENTION: **Mr. Dean Evans, Electrical Supervisor**

Subject: **1999 High Voltage Maintenance**

Our Reference #: **6621**

Dear Sir:

During June this year, we completed the ***Preventive Maintenance Program*** on the high voltage power apparatus located at your site. This work was carried out to the specifications outlined in tender proposal #48 (98-10).

The following sections are included in the report:

- **Deficiencies and recommendations**
- **Inspection Sheets**

Intent

The intent of this program was to evaluate and report on the condition of the high and low voltage equipment in your main and unit substations. This evaluation would detect any problems in their early stages, indicating potential problems in your system that would eventually lead to equipment failure.

Black & McDonald

Technical Field Service Department

31 Pullman Court, Scarborough, Ontario M1X 1E4. Phone: (416)-298-9977 Fax: (416)-298-2907

Findings

The problem areas together with detailed recommendations can be found in section "A". Detailed information pertaining to any of the deficiencies listed in this section can be reviewed with the individual test sheets compiled in section "B". In-order to avoid any unexpected downtime we would recommend taking the necessary corrective measures listed in section "A".

Should you require any further assistance or information, please do not hesitate to contact our office at your convenience. We thank you for the opportunity to have been of service.

Yours sincerely,

BLACK & McDONALD LIMITED

R.P. (Rodger) Morgan

Technical Field Service Division

Black & McDonald

Technical Field Service Department

31 Pullman Court, Scarborough, Ontario M1X 1E4. Phone: (416)-298-9977 Fax: (416)-298-2907

"A" DEFICIENCIES & RECOMMENDATIONS

Black & McDonald

Technical Field Service Department

31 Pullman Court, Scarborough, Ontario M1X 1E4. Phone: (416)-298-9977 Fax: (416)-298-2907

Deficiencies and Recommendations

Main Incoming Switchgear

1.) Main Feeder "DIP" Pole

Deficiency:

The main fuses on this pole were found to be out of co-ordination with the downstream switchgear fuses. Both were sized at an amperage of 150E. Due to the subsequent interruptions caused by cable failures, these have been replaced and the pole-mounted fuses re-sized to 200E.

Recommendation:

Review sizing and speed (TCC #) requirements with the supply authority. Ensure stock of these S&C SMU-20 style fuse units for future ready availability.

2.) Main 27.6kV Incoming Switch

Deficiency:

The Blue/ Cϕ arcing interrupter was found to be defective.

Recommendation:

Replace this S&C interrupter unit.

3.) Feed to Eurasia Pavilion

Deficiency:

The B & C phase interrupters on this switch measure over the readable scale in both positions. They are defective.

Recommendation:

Replace these two arcing interrupters.

4.) All Fused Switch Cells

Deficiency:

Due to the power cable failures and the resulting numerous fuse operations, the spare fuse stock in these feeder cells has been significantly depleted.

Recommendation:

Restock the spare fuse inventory.

North America Pavilion

5.) Loop Feed to Service Building

Deficiency:

Flash marks were observed on both the left phase barrier and beside the associated lightning arrestor.

Recommendation:

Replace the phase barrier and touch up cell as required.

6.) Paddock Feeders

Deficiency:

Only one spare fuse link is available in the switch/ fuse compartment.

Recommendation:

Restock the spare fuse inventory.

Black & McDonald

Technical Field Service Department

31 Pullman Court, Scarborough, Ontario M1X 1E4. Phone: (416)-298-9977 Fax: (416)-298-2907

Entrance/ Administration Building

7.) Feeder to Village Edge South

Deficiency:

Only one spare fuse link is available in the switch/ fuse compartment.

Recommendation:

Restock the spare fuse inventory.

Africa Pavilion

8.) Paddock Feeder

Deficiency:

No spare fuse links are present in this feeder cell.

Recommendation:

Restock the spare fuse inventory.

9.) Main Secondary Breaker

Deficiency:

This FPE 75H-2 (s/n. TH-4126-72) 3000 Amp circuit breaker was found to be mechanically problematic. The breaker failed to consistently trip even though the trip bar was fully engaged. The unit was extensively investigated during the maintenance shutdown and repaired to serviceable condition. ***Note that this field repair should only be considered as a temporary fix!***

Recommendation:

Because of the nature of the discovered defects, this unit will require thorough stripping and rebuilding/ service. This will require the removal of the circuit breaker from service and may necessitate the installation of temporary generator power as per your needs.

Black & McDonald

Technical Field Service Department

31 Pullman Court, Scarborough, Ontario M1X 1E4. Phone: (416)-298-9977 Fax: (416)-298-2907

10.) MCC1 Circuit Breaker

Note:

Due to the time and personnel involved in investigating of the main circuit breaker, the other smaller breaker designated as "MCC1" was not tested. This unit has been previously reported as problematic and may also need additional servicing.

Indo-Malaya Pavilion

11.) Feeder to Entrance Facilities

Deficiency:

The Bϕ cable terminator in this switch cell was found with a top porcelain skirt broken.

Recommendation:

The damaged area was sealed with contact cement. No further action is required at the present time.

12.) Indo-Malaya Paddock Feeder

Deficiency:

The arc interrupter operator (attached to the switchblade) was found to be broken. As a result the interrupter now does not function.

Recommendation:

To restore the interrupter's functionality, the entire Load Interrupter switchblade arm will have to be replaced.

13.) Indo-Malaya Paddock Feeder

Deficiency:

No spare fuse links are present in this cell.

Recommendation:

Restock the spare fuse inventory.

14.) Main Secondary & DP MB Circuit Breakers

Deficiency:

- The front flash barrier is missing on the "Main …" C.B.
- The front flash barriers are cracked on the "DP MB" C.B.
- "DP MB" mechanism was found to be sticking.

Recommendation:

- The "DP MB" mechanism was restored to proper operation. No further action is required.
- Replace the flash barriers on both circuit breakers.

Eurasia Pavilion

15.) Paddock Feeders (Centre & South)

Deficiency:

The Kirk RE12023 interlock is inoperable due to the switch handle being bent out of position. The switch is still operational.

Recommendation:

If full functionality is desired, then the switch handle must be replaced. If this is not a priority, then the switch is presently functional and requires no further action.

16.) Paddock Feeders (Centre & South)

Deficiency:

Only one spare fuse link is available in the switch/ fuse compartment.

Recommendation:

Restock the spare fuse inventory.

17.) Eurasia Pavilion Transformer T-1

Deficiency:

The top skirt of the H3 primary bushing was found to be cracked.

Bushing Spec.: Westinghouse T1; DWG. No. 25kV400A; S.O. 544C638G05

Recommendation:

The crack was sealed with epoxy. No further action is required at the present time. ***The condition of this bushing should be monitored during subsequent shutdowns.*** Subsequent deterioration will require bushing replacement in this Askarel (PCB)-filled equipment.

Submersible & Pad-Mount Transformers

18.) Submersible Transformers (General)

Note:

The majority of the approximately 50 units on site are more than 25 years old. These units are approaching the end of their operational service lives. While no one can accurately predict the exact moment of failure for each unit, recent events have shown that they may fail at any time.

A graduated replacement program should be considered by engineering and procurement staff so as to modernise the existing transformer inventory, and prevent unnecessary downtime caused by failures.

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19.) Submersible Transformers Oil Levels

Deficiency:

Several of the submersible transformers were observed with the oil level below the manufacturer's recommended fill line. This is likely as a result of there only being a small quantity of oil in the units and them having been sampled on previous occasions.

Recommendation:

Purchase a barrel of Voltesso 35 electrical grade insulating oil (or equivalent) to be used to top up the units as needed during future shutdowns. This barrel should be stored in an area where it will be sheltered from elements (moisture, etc.) that can degrade its properties.

20.) Submersible Vault #1 (Fed from Service Building)

Deficiency:

The "H1B" elbow on this unit (s/n. 871935) was found with burn marks on it.

Recommendation:

The elbow and transformer bushing insert should be replaced in the near future

21.) Submersible Vault #32 (Fed from N. America)

Deficiency:

The manhole gasket on this Red Phase transformer (s/n. 861949) is in poor condition. Improper sealing of the unit can allow the entrance of moisture and degradation of the oil.

Recommendation:

Replace this access cover gasket.

22.) Interfacial Tension (IFT) Levels

Deficiency:

Interfacial tension is a measure of the barrier between the oil and water. A lowering of this level is an indication that oil is beginning to degrade.

A number of the transformers had borderline IFT levels. The worst of these is the Vault #18 unit (s/n. LO721-1), which has a measured level of 18.2 dynes/ cm; the N.E.T.A. standard recommended minimum is 32 dynes/ cm.

Recommendation:

The Vault #18 transformer should be sampled again within 6 months both to confirm the initial reading and trend for deterioration.

23.) Weston Station

Note:

This unit substation was reported to be in poor condition. The station should be shutdown during daylight hours for a thorough evaluation.

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"B" INSPECTION SHEETS

Black & McDonald

Technical Field Service Division
31 Pullman Court Scarborough, Ontario. M1X 1E4 Phone: (416) 298-9977 Fax: (416) 298-2907

METROPOLITAN TORONTO ZOO
Infrared Inspection Report

Prepared For: Dean Evans
Date: July 27, 1999

Prepared By: Kevin Josephs
Our Reference: 6621

Black & McDonald

Technical Field Service Division
31 Pullman Court Scarborough, Ontario. M1X 1E4 Phone: (416) 298-9977 Fax: (416) 298-2907

July 27,1999

Metropolitan Toronto Zoo
361A Old Finch Avenue
Scarborough, Ontario
M1B 5K7

ATTENTION: Mr. Dean Evans
Subject: *Infrared Inspection Report*
Our Reference: *6621*

Dear Sir:

We have completed your infrared inspection on June 9, 1999. There is list of the areas scanned in this report as well as our findings and recommendations for your review and comment.

Within the report you will find an Infrared Survey Sheet that displays a Thermogram window, below that image there is a **'Profile'** window. This window measures the object's temperature along that line in the form of a line graph.

The deficiencies found during the inspection do not warrant any quotation for parts.

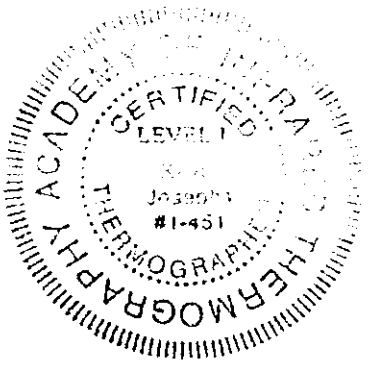
We advise that in our opinion the electrical power apparatus as covered in the report, having been inspected, tested and not yet repaired. Sub-stations located in the Indo & Austraialasia Pavilion appears to be in good condition except what's noted f in the applicable section of this report.

If any questions arise regarding these matters, please feel free to contact the undersigned at any time.

Sincerely,

BLACK & McDONALD LIMITED

K. (Kevin) Josephs
Senior Infrared Technologist
Technical Field Service Division



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Purpose:

The purpose of an infrared inspection is to detect heat. Heating is normal in an electrical system since it is caused by the flow of current through a conductor. Therefore, the heat we are searching for is heat, which is abnormal. Unusual heating conditions are caused by several phenomena such as:

- Poor Connections Due To:
  - Looseness
  - Dirt
  - Oxidation
  - Over loading
- Other Conditions Producing Heat Are:
  - Load Imbalances
  - Harmonics

Survey Intent:

It is the intent of this survey to act as a predictive tool in order to detect unforeseen problems in the specified areas of your electrical distribution system. Further, our report will satisfy all requests by your insurance company with respect to the completion of an infrared scanning program.

Background:

Every body emits infrared heat radiation because of its temperature. Infrared Thermovision systems detect the energy and convert it into a visual picture. Infrared radiation is a direct and proportional function of the body temperature and, by utilizing a special feature (Isotherm) on the infrared System, the temperature differentials can be accurately determined.

The isotherm will appear on a visual image as a series of bright green dots, which have a correspondence to a specific temperature reading.

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Applications:

Infrared technology is used industry wide as a preventive maintenance tool. All major power consumers use this type of survey on a regular basis. The cost savings associated with the reduction of preventive maintenance man-hours have proved time and time again to justify the cost of the original survey.

Results:

The results are presented in the form of a video print out of the thermal image as seen by the infrared system operator. A corresponding real life picture of the area in question is also supplied. This allows for easier location of the hot spot, as sometimes it is difficult for the untrained eye to perceive detail from the thermograph.

Technical data relative to the suspect area is also provided. This includes the exact identity of the suspect area and/ or device and/ or component, the load currents, our comments as to the suspected cause and our recommendations pertaining to corrective action.

If the electrical system is operating at 60% of its rated capacity then the following rule of thumb may be used to determine the severity of the condition.

Temperature Rise	Classification
1 - 10 Degrees Celsius	Minor Problem. Repair At Your Convenience
10 - 35 Degrees Celsius	Intermediate Problem. Repair In The Next Three Months
+35 Degrees Celsius	Serious Problem. Make Repairs Immediately

Corrective Action:

Infrared technology is one of the truly predictive maintenance tools available today. However, it is only as useful as the corrective action taken to remedy problems, which are discovered.

Therefore, when infrared scanning is carried out it should be done during a period of time when the operation of the facility is as high as possible. It should also be carried out in conjunction with and prior to substation maintenance inspections.

In this way detected problem areas can be corrected with a minimum amount of disruption to the normal operation of the facility.

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Areas Scanned

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Indo Pavilion

- *Main Electrical Room*
- *Old Orang Holding*
- *New Orang Holding*
- *Lighting Panel(s) Around Exhibit Area*
- *Gaur Building #1 & #2*
- *MCC Board* ***(Booster Switch & Fan #16 Door Didn't Open)***

African Pavilion

- *Main Electrical Room*
- *Lighting Panel(s) Around Exhibit Area*

America's Pavilion Building

- *Pump Room*
- *Electrical Room*
- *Fan Room*
- *Exhibit Area*

Australasia

- *Main Electrical Room*
- *Boiler Room*
- *Panel(S) Around the Exhibit Area*

Education & Main Gift Shop

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Entrance Facilities

(Front Office Room Locked)

Animal Hospital Building

North Service Building

- *Main Floor*
- *Shop Area*
- *Basement*
- *3rd Floor*
- *Main Electrical Room*

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Inspection Results and Recommendations

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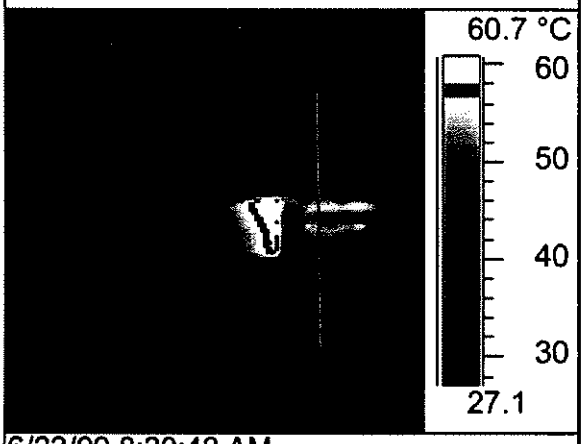
Infrared Survey Sheet

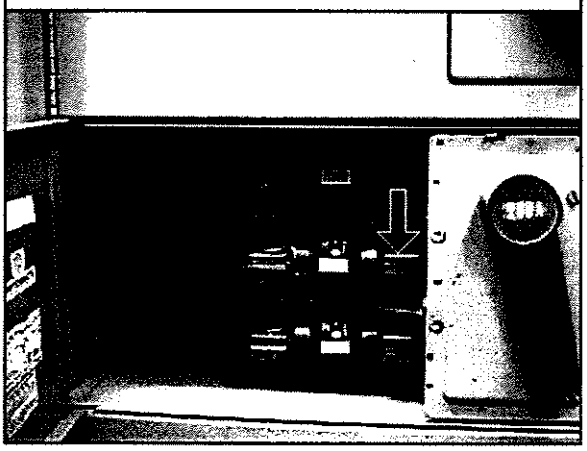
Job No.: 6621
Customer: Metropolitan Toronto Zoo
Site Location: Toronto, Ontario
Equipment I.D.: F.P.E. 200A 120/208V Disconnect (Auto Transfer Sw.)
Equipment Location: Indo Pavilion Main Electrical Room
Inspection Date: 5/2/89 1:18:15 AM

IR - I0000100.031



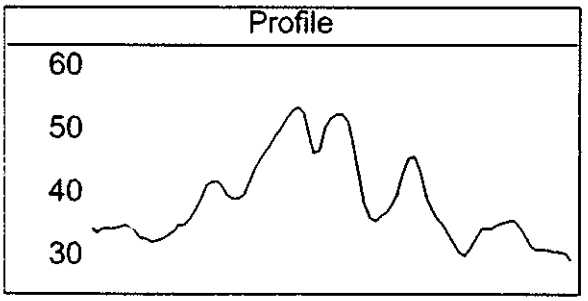
6/23/99 8:30:42 AM

Photo - IMAGE18.BMP



Surface Profile Minimum Temperature:	**29.7 °C**
Isotherm Area Temperature:	**58.0 °C**
Surface Profile Maximum Temperature:	**54.0 °C**

Profile



Status

SCANNER DATA

Scanner Type	THV470 SWB
Serial Number	73010
Level	415
Sens	5
Aperture	0
Filter	NOF
Lens	20

IMAGE OBJ. PAR.

Emissivity	0.84
Amb. temp.	23.7 °C
Atm. temp.	24.8 °C
Object dist.	1.0 m
Rel Humidity	0.50
Transmission	0.99

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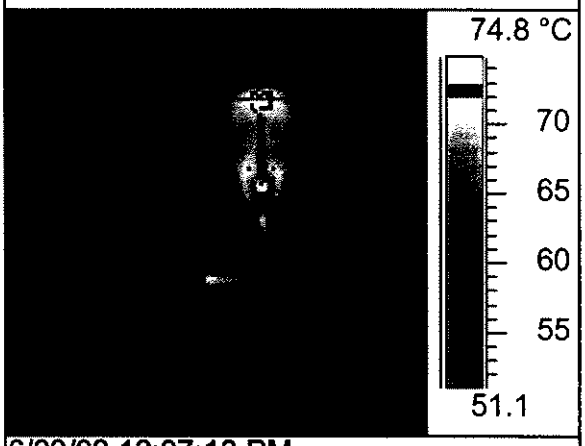
Infrared Survey Sheet

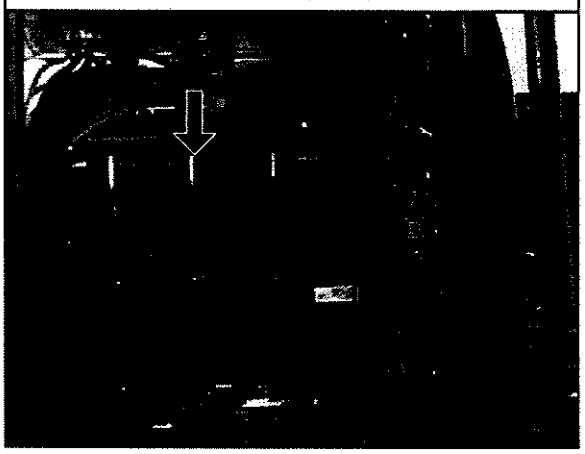
Job No.:	**6621**
Customer:	**Metropolitan Toronto Zoo**
Site Location:	**Toronto, Ontario**
Equipment I.D.:	**Square 'D' 60A Starter Fan #5 General Supply-EU1001**
Equipment Location:	**Austrialasia Pavilion**
Inspection Date:	**5/2/89 5:37:40 AM**

IR - I0000100.032



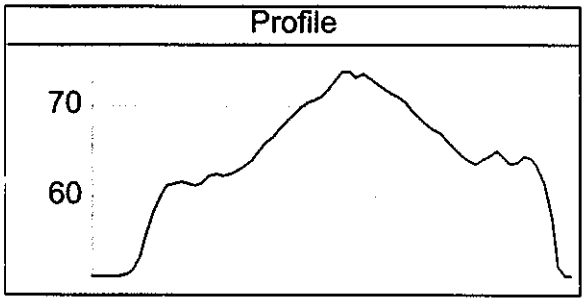
6/23/99 12:07:13 PM

Photo - IMAGE19.BMP



Surface Profile Minimum Temperature:	**<51.1 °C**
Isotherm Area Temperature:	**72.9 °C**
Surface Profile Maximum Temperature:	**73.9 °C**

Profile



Status

SCANNER DATA	
Scanner Type	THV470 SWB
Serial Number	73010
Level	584
Sens	5
Aperture	0
Filter	NOF
Lens	20
IMAGE OBJ. PAR.	
Emissivity	0.81
Amb. temp.	22.9 °C
Atm. temp.	25.2 °C
Object dist.	1.0 m
Rel Humidity	0.50
Transmission	0.99

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Inspection Recommendations

NB. Please refer to individual infrared inspection sheets by the designation given in the PHOTO window

1. F.P.E. 200A 120/208V Disconnect (Auto Transfer Switch) Main Electrical Room (Indo Pavilion)

Description: *The Centre phase line end fuse clip area recorded a maximum thermal rise of 54.0 ℃, thus creating a temperature rise of 30.3 ℃ above ambient. The load taken at that time was Top $\phi \cong 55$ Amps, Centre $\phi \cong 70$ Amps, and the Bottom $\phi \cong 42$ Amps.*

Required Action: *Checking this area for proper connection and removing any oxidized agents is necessary to correct the anomaly.*

2. Square 'D' 60A Starter (Fan #5 General Supply – EU1001 Austrialasia Pavilion

Description: *The Centre phase blade contact area recorded a maximum thermal rise of 73.9 ℃, thus creating a temperature rise of 51.0 ℃ above ambient. All three phases were balanced at 40 Amps.*

Required Action: *This area needs to disassembled, cleaned and checked for proper connection.*

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Main Incoming
Outdoor 27.6kV Switchgear

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TECHNICAL FIELD SERVICE DIVISION

Special Projects Group

Client Information

Customer	Toronto Zoo	**Date**	June 15, 1999
File Number	6621	**Tested By**	RPM/KH
Location	361A Old Finch Ave., Scarborough, Ontario		
Equipment I.D.	Main Outdoor Incoming		
Substation	Pole-mounted Supply Fuse		

High Voltage Power Fuse

Fuse Holder Nameplate Data				
Manufacturer	S&C	**Voltage**	25	**kVolt**
Type	SMU-20 Fuse Unit	**Current**		**Amps**
Style/Cat #		**Serial #**		

Fuse Link Nameplate Data			
Type	SMU-20 Fuse Unit	**TCC**	119-2
Style/Cat #		**Amps**	150 E

Mechanical Inspections

Description of Inspection	*Status*	*Comments*
Operating Mechanism	OK	
Contact Surfaces	OK	
Contact Penetration	OK	
Contact Alignment	OK	
Fuse Barrel	OK	
Connector Condition	OK	
Insulator Condition	OK	
Phase Barrier Condition	N/A	
Support Structure Condition	OK	
Spare Fuses	?	None seen. Provided by Toronto Hydro

Electrical Tests

Test Description	*ϕA*	*ϕ B*	*ϕ C*	*A/B*	*B/C*	*C/A*
Insulation Resistance (MΩ)						
Contact Resistance (μΩ)	458	644	496			
Results Satisfactory	These units have subsequently been replaced.					

T.S.

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TECHNICAL FIELD SERVICE DEPARTMENT

Special Projects Group

Client Information

Customer	Toronto Zoo	**Date**	June 15, 1999
File Number	6621	**Tested By**	RPM/KH/TA
Location	361A Old Finch Ave., Scarborough, Ontario		
Equipment I.D.	Main Outdoor Incoming		
Substation	Main 27.6 kV		

High Voltage Air/Load Break Switch

Nameplate Data

Manufacturer	S&C	**Voltage**	27	**kVolts**
Type	Alduti Indoor	**Current**	600	**Amps**
Style #		**B.I.L.**	150	**kVolts**
Cat #	34163	**Serial #**	---	

Mechanical Inspections

Description of Inspection	*Status*	*Comments*
Key Interlock	OK	
Operating Mechanism	OK	
Operating Handle Grounding	OK	
Grounding Mat	N/A	
Stationary Contact Surfaces	OK	
Moving Contact Surfaces	OK	
Arcing Contact Surfaces	OK	
Contact Alignment	OK	
Arcing Interrupter	POOR	Blue O Defective
Connector Condition	OK	
Insulator Condition	OK	
Phase Barrier Condition	OK	
Support Structure Condition	OK/ Fair	Some internal rust damage

Electrical Tests

Test Description	*ϕA*	*ϕB*	*ϕC*	*A/B*	*B/C*	*C/A*
Insulation Resistance (GΩ)	50.5	28	12.3			
Contact Resistance (μΩ)	56	63	55			
Arc Interrupter Res.(Ω)	0.6	0.7	High			
Results Satisfactory	Fair – See Recommendations					

T.S.

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TECHNICAL FIELD SERVICE DEPARTMENT

Special Projects Group

Client Information

Customer	Toronto Zoo	**Date**	June 15, 1999
File Number	6621	**Tested By**	KH/ TA
Location	361A Old Finch Ave., Scarborough, Ontario		
Equipment I.D.	Feed to Eurasia Pavilion		
Substation	Main Outdoor 27.6 kV		

High Voltage Air/Load Break Switch

Nameplate Data

Manufacturer	S&C	**Voltage**	27	**kVolts**
Type	Alduti Interrupter	**Current**	600	**Amps**
Style #		**B.I.L.**	150	**kVolts**
Cat #	34563R4-T2	**Serial #**	---	

Mechanical Inspections

Description of Inspection	*Status*	*Comments*
Key Interlock	OK	Kirk # RE 12045
Operating Mechanism	OK	
Operating Handle Grounding	OK	
Grounding Mat	N/A	
Stationary Contact Surfaces	OK	Cleaned
Moving Contact Surfaces	OK	Cleaned
Arcing Contact Surfaces	OK	Cleaned
Contact Alignment	OK	
Arcing Interrupter	POOR	High Resistance in Closed Position
Connector Condition	OK	
Insulator Condition	OK	
Phase Barrier Condition	OK	
Support Structure Condition	OK	

Electrical Tests

Test Description	*ϕ A*	*ϕ B*	*ϕ C*	*A/B*	*B/C*	*C/A*
Insulation Resistance (MΩ)						
Contact Resistance (μΩ)	51	53	57			
Arc Interrupter Res.(Ω)	1.3	*	*			
Results Satisfactory	See Recommendations					

T.S.

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TECHNICAL FIELD SERVICE DIVISION

Special Projects Group

Client Information

Customer	Toronto Zoo	**Date**	June 15, 1999
File Number	6621	**Tested By**	KH/ TA
Location	361A Old Finch Ave., Scarborough, Ontario		
Equipment I.D.	Feeder to Eurasia Pavilion		
Substation	Main Outdoor 27.6 kV		

High Voltage Power Fuse

Fuse Holder Nameplate Data				
Manufacturer	S&C	**Voltage**	34.5	**kVolt**
Type	SM-5S	**Current**	300E	**Amps**
Style/Cat #	86644R1	**Serial #**		

Fuse Link Nameplate Data			
Type	SM-5	**TCC**	153-4
Style/Cat #	134250R4	**Amps**	150E

Mechanical Inspections

Description of Inspection	*Status*	*Comments*
Operating Mechanism	OK	
Contact Surfaces	OK	
Contact Penetration	OK	
Contact Alignment	OK	
Fuse Barrel	OK	
Connector Condition	OK	
Insulator Condition	OK	
Phase Barrier Condition	OK	
Support Structure Condition	OK	
Spare Fuses	Fair	2 spares in cell during inspection

Electrical Tests

Test Description	*ϕA*	*ϕ B*	*ϕ C*	*A/B*	*B/C*	*C/A*
Insulation Resistance (MΩ)						
Contact Resistance (μΩ)	630	828	636			

Results Satisfactory	See Recommendations

T.S.

T.S. HV_Fuse

Black & McDonald

TECHNICAL FIELD SERVICE DEPARTMENT

Special Projects Group

Client Information

Customer	Toronto Zoo	**Date**	June 15, 1999
File Number	6621	**Tested By**	RPM/KH/TA
Location	361A Old Finch Ave., Scarborough, Ontario		
Equipment I.D.	Feeder to Service Building		
Substation	Main Outdoor 27.6 kV Incoming		

High Voltage Air/Load Break Switch

Nameplate Data

Manufacturer	S&C	**Voltage**	27	**kVolts**
Type	Alduti	**Current**	600	**Amps**
Style #		**B.I.L.**	150	**kVolts**
Cat #	34563R4-T2	**Serial #**		

Mechanical Inspections

Description of Inspection	*Status*	*Comments*
Key Interlock	OK	Kirk RE 12043
Operating Mechanism	OK	
Operating Handle Grounding	OK	
Grounding Mat	N/A	
Stationary Contact Surfaces	OK	Cleaned
Moving Contact Surfaces	OK	Cleaned
Arcing Contact Surfaces	OK	Cleaned
Contact Alignment	OK	
Arcing Interrupter	OK	
Connector Condition	OK	
Insulator Condition	OK	
Phase Barrier Condition	OK	
Support Structure Condition	OK	

Electrical Tests

Test Description	*ϕ A*	*ϕ B*	*ϕ C*	*A/B*	*B/C*	*C/A*
Insulation Resistance (MΩ)						
Contact Resistance (μΩ)	49	42	47			
Arc Interrupter Res.(Ω)	1.3	1.0	0.5			

Results Satisfactory	OK

T.S.

Black & McDonald

TECHNICAL FIELD SERVICE DIVISION

Special Projects Group

Client Information

Customer	Toronto Zoo	**Date**	June 15, 1999
File Number	6621	**Tested By**	RPM/KH/TA
Location	361A Old Finch Ave., Scarborough, Ontario		
Equipment I.D.	Feeder to Service Building		
Substation	Main Outdoor 27.6kV Incoming		

High Voltage Power Fuse

Fuse Holder Nameplate Data				
Manufacturer	S&C	**Voltage**	34.5	**kVolt**
Type	SM-5D	**Current**	300	**Amps**
Style/Cat #	86644R1	**Serial #**		

Fuse Link Nameplate Data			
Type	SM-5	**TCC**	153-4
Style/Cat #	134250R4	**Amps**	150E

Mechanical Inspections

Description of Inspection	*Status*	*Comments*
Operating Mechanism	OK	
Contact Surfaces	OK	
Contact Penetration	OK	
Contact Alignment	OK	
Fuse Barrel	OK	
Connector Condition	OK	
Insulator Condition	OK	
Phase Barrier Condition	OK	
Support Structure Condition	OK	
Spare Fuses	Poor	One only during inspection

Electrical Tests

Test Description	*ϕA*	*ϕ B*	*ϕ C*	*A/B*	*B/C*	*C/A*
Insulation Resistance (MΩ)						
Contact Resistance (μΩ)	688	627	623			
Results Satisfactory	Spares Required.					

T.S.

T.S. HV_Fuse

Black & McDonald

Technical Field Service Department

31 Pullman Court, Scarborough, Ontario M1X 1E4. Phone: (416)-298-9977 Fax: (416)-298-2907

North America Pavilion

Black & McDonald

TECHNICAL FIELD SERVICE DIVISION

Special Projects Group

Client Information

Customer	Toronto Zoo	**Date**	June 14, 1999
File Number	6621	**Tested By**	JRK
Location	361A Old Finch Ave., Scarborough, Ontario		
Equipment I.D.	Loop Feeder to African Pavilion		
Substation	North American Pavilion		

High Voltage Air/Load Break Switch

Nameplate Data

Manufacturer	S&C	**Voltage**	27	**kVolts**
Type	Alduti	**Current**	600	**Amps**
Style #		**B.I.L.**	150	**kVolts**
Cat #	34063R2	**Serial #**		

Mechanical Inspections

Description of Inspection	*Status*	*Comments*
Key Interlock	N/A	
Operating Mechanism	OK	
Operating Handle Grounding	N/A	
Grounding Mat	N/A	
Stationary Contact Surfaces	OK	
Moving Contact Surfaces	OK	
Arcing Contact Surfaces	OK	
Contact Alignment	OK	
Arcing Interrupter	OK	
Connector Condition	OK	
Insulator Condition	OK	
Phase Barrier Condition	OK	
Support Structure Condition	OK	

Electrical Tests

Test Description	*ϕA*	*ϕB*	*ϕC*	*A/B*	*B/C*	*C/A*
Insulation Resistance (MΩ)						
Contact Resistance (μΩ)	90	82	92			
Arc Interrupter Res.(Ω)	0.4	0.4	0.4			
Results Satisfactory	OK					

T.S.

T.S. HV_ABS

Black & McDonald

TECHNICAL FIELD SERVICE DIVISION

Special Projects Group

Client Information

Customer	Toronto Zoo	**Date**	June 14, 1999
File Number	6621	**Tested By**	JRK
Location	361A Old Finch Ave., Scarborough, Ontario		
Equipment I.D.	Loop Feed to Service Building		
Substation	North American Pavilion		

High Voltage Air/Load Break Switch

Nameplate Data

Manufacturer	S&C	**Voltage**	27	**kVolts**
Type	Alduti	**Current**	600	**Amps**
Style #		**B.I.L.**	150	**kVolts**
Cat #	34063R2	**Serial #**		

Mechanical Inspections

Description of Inspection	*Status*	*Comments*
Key Interlock	N/A	
Operating Mechanism	OK	
Operating Handle Grounding	N/A	
Grounding Mat	N/A	
Stationary Contact Surfaces	OK	
Moving Contact Surfaces	OK	
Arcing Contact Surfaces	OK	
Contact Alignment	OK	
Arcing Interrupter	OK	
Connector Condition	OK	
Insulator Condition	OK	
Phase Barrier Condition	Fair Poor	Flash Marks Present on Barrier, etc.
Support Structure Condition	OK	

Electrical Tests

Test Description	*ϕ A*	*ϕ B*	*ϕ C*	*A/B*	*B/C*	*C/A*
Insulation Resistance (MΩ)						
Contact Resistance (μΩ)	90	81	80			
Arc Interrupter Res.(Ω)	0.4	0.3	0.5			
Results Satisfactory	*See Recommendations*					

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TECHNICAL FIELD SERVICE DIVISION

Special Projects Group

Client Information

Customer	Toronto Zoo	**Date**	June 14, 1999
File Number	6621	**Tested By**	JRK
Location	361A Old Finch Ave., Scarborough, Ontario		
Equipment I.D.	Paddock Feeders		
Substation	North American Pavilion		

High Voltage Air/Load Break Switch

Nameplate Data				
Manufacturer	S&C	**Voltage**	27	**kVolts**
Type	Alduti	**Current**	600	**Amps**
Style #		**B.I.L.**	150	**kVolts**
Cat #	34563R4-T2	**Serial #**		

Mechanical Inspections

Description of Inspection	*Status*	*Comments*
Key Interlock	OK	Kirk RE12053
Operating Mechanism	OK	
Operating Handle Grounding	N/A	
Grounding Mat	N/A	
Stationary Contact Surfaces	OK	
Moving Contact Surfaces	OK	
Arcing Contact Surfaces	Fair	Surfaces pitted
Contact Alignment	OK	
Arcing Interrupter	OK	
Connector Condition	OK	
Insulator Condition	OK	
Phase Barrier Condition	OK	
Support Structure Condition	OK	

Electrical Tests

Test Description	*ϕA*	*ϕB*	*ϕC*	*A/B*	*B/C*	*C/A*
Insulation Resistance (MΩ)	92	112	153	272	280	300
Contact Resistance (μΩ)	79	82	77			
Arc Interrupter Res.(Ω)	0.4	0.4	0.3			
Results Satisfactory	OK					

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TECHNICAL FIELD SERVICE DIVISION

Special Projects Group

Client Information

Customer	Toronto Zoo	**Date**	June 14, 1999
File Number	6621	**Tested By**	JRK
Location	361A Old Finch Ave., Scarborough, Ontario		
Equipment I.D.	Paddock Feeders		
Substation	North American Pavilion		

High Voltage Power Fuse

Fuse Holder Nameplate Data				
Manufacturer	S&C	**Voltage**	27.6	**kVolt**
Type	SM-5	**Current**	300E	**Amps**
Style/Cat #		**Serial #**		

Fuse Link Nameplate Data			
Type	SM-5	**TCC**	119-4
Style/Cat #	264125-R4	**Amps**	80E

Mechanical Inspections

Description of Inspection	*Status*	*Comments*
Operating Mechanism	OK	
Contact Surfaces	OK	
Contact Penetration	OK	
Contact Alignment	OK	
Fuse Barrel	OK	
Connector Condition	OK	
Insulator Condition	OK	
Phase Barrier Condition	OK	
Support Structure Condition	OK	
Spare Fuses	Fair	One Spare Present in Cell

Electrical Tests

Test Description	*ϕA*	*ϕ B*	*ϕ C*	*A/B*	*B/C*	*C/A*
Insulation Resistance (MΩ)						
Contact Resistance (μΩ)	1005	1100	1060			
Results Satisfactory	OK					

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TECHNICAL FIELD SERVICE DIVISION

Special Projects Group

Client Information

Customer	Toronto Zoo	**Date**	June 14, 1999
File Number	6621	**Tested By**	JRK
Location	361A Old Finch Ave., Scarborough, Ontario		
Equipment I.D.	American Pavilion Trans. #5		
Substation	North American Pavilion		

High Voltage Air/Load Break Switch

Nameplate Data

Manufacturer	S&C	**Voltage**	27.6	**kVolts**
Type	Alduti	**Current**	600	**Amps**
Style #		**B.I.L.**	150	**kVolts**
Cat #	34563R4-T2	**Serial #**		

Mechanical Inspections

Description of Inspection	*Status*	*Comments*
Key Interlock	N/A	
Operating Mechanism	OK	
Operating Handle Grounding	N/A	
Grounding Mat	N/A	
Stationary Contact Surfaces	OK	
Moving Contact Surfaces	OK	
Arcing Contact Surfaces	OK	
Contact Alignment	OK	
Arcing Interrupter	OK	
Connector Condition	OK	
Insulator Condition	OK	
Phase Barrier Condition	OK	
Support Structure Condition	OK	

Electrical Tests

Test Description	*ϕ A*	*ϕ B*	*ϕ C*	*A/B*	*B/C*	*C/A*
Insulation Resistance (MΩ)						
Contact Resistance (μΩ)	37	37	40			
Arc Interrupter Res.(Ω)						
Results Satisfactory	OK					

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TECHNICAL FIELD SERVICE DIVISION

Special Projects Group

Client Information

Customer	Toronto Zoo	**Date**	June 14, 1999
File Number	6621	**Tested By**	RPM/ TA
Location	361A Old Finch Ave., Scarborough, Ontario		
Equipment I.D.	North American Pavilion Trans. #5		
Substation	North American Pavilion		

High Voltage Power Fuse

Fuse Holder Nameplate Data				
Manufacturer	S&C	**Voltage**	27.6	**kVolt**
Type	SM-5	**Current**	300	**Amps**
Style/Cat #	86644R1	**Serial #**		

Fuse Link Nameplate Data			
Type	SM-5	**TCC**	153-4
Style/Cat #	134025R4	**Amps**	15E

Mechanical Inspections

Description of Inspection	*Status*	*Comments*
Operating Mechanism	OK	
Contact Surfaces	OK	
Contact Penetration	OK	
Contact Alignment	OK	
Fuse Barrel	OK	
Connector Condition	OK	
Insulator Condition	OK	
Phase Barrier Condition	OK	
Support Structure Condition	OK	
Spare Fuses	OK	3 Spares in Cell

Electrical Tests

Test Description	*ϕA*	*ϕ B*	*ϕ C*	*A/B*	*B/C*	*C/A*
Insulation Resistance (MΩ)	>999	>999	>999	>999	>999	>999
Contact Resistance (μΩ)	6190	6260	6050			
Results Satisfactory	OK					

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TECHNICAL FIELD SERVICE DIVISION

Special Projects Group

Client Information

Customer	Toronto Zoo	**Date**	June 14, 1999
File Number	6621	**Tested By**	RPM
Location	361A Old Finch Ave., Scarborough, Ontario		
Equipment I.D.	T5		
Substation	North American Pavilion		

Power Transformer -Electrical

Nameplate Data

Manufacturer	Westinghouse		**Vector Group**	Y-Y	
Type	LNAN		**Serial #.**	827695	
Neutral	Solid		**Liquid Type/Vol**	Askarel 200	**Gal**
Rating	300/ 336	**kVA**	**Total Weight**	7020	**lbs.**
Impedance	5.4	**%**	**Primary Voltage**	27.6/ 16	**kVolt**
Phase	3	**ϕ**	**Secondary Voltage**	208/ 120	**Volt**
Frequency	60	**Hz**	**BIL**	150/ 45	**kVolt**

Insulation Tests

Insulation Resistance @ 5k / 1k VDC	**Prim. With Sec. Grounded**	**Sec. With Prim. Grounded**	**Prim. & Sec. To Ground**
MΩ	31.6	31.0	
Corrected to 20 °C.			

	CH-L + G	**CH-G**	**CH-L**	**CL-G**	**CL-H + G**
Cap (pF)		280		9154	
Corr. 20 °C					
Dis. Fact.(%)		5.70		6.56	
Corr. 20 °C.					

Turns Ratio Tests

Tap	**Primary Volts**	**Calculated Ratio**	**X0-X1 H0-H1**	**X0-X2 H0-H2**	**X0-X3 H0-H3**
1					
2					
3	27,600	0.754	0.746	0.746	0.746
4					
5					

Tap Position Found & Left	3 (27,600V)
Results Satisfactory	OK

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TECHNICAL FIELD SERVICE DEPARTMENT

Special Projects Group

Client Information

Customer	Toronto Zoo	**Sample Date**	June 14, 1999
File Number	6621	**Sampled By**	RPM
Location	361A Old Finch Ave., Scarborough, Ontario		
Equipment I.D.	T5		
Substation	North American Pavilion		

Oil Analysis

Transformer Data

Manufacturer	Westinghouse	**Primary Volts**	27.6/ 16	**kVolts**
Type	LNAN	**Rating**	300/ 336	**kVA**
Serial No.	827695	**Liquid Volume**	200	**Gals.**

Laboratory Tests

Type of Test	ASTM No.	Acceptable Limits	Test Results	
				1999
Dielectric Breakdown	D877	30 kV		46.7
Neutralization Number	D974	0.05 Max. Mg Koh/G		0.008
Interfacial Tension	D971	32 Dynes/ Cm Min.		N/A
Specific Gravity	D1298	0.84 - 0.91 (Oil)		1.520
Colour	D1500	≤3.5		0.5
Visual Condition	D1524	Clear		Clear
Water Content	D1533	30 ppm (<69kV)		
Power Factor	D924	1.0 % Max @ 25 °C		
PCB Content	D4059	50 ppm Max.		
Inhibitor	D2668	≥0.20%		
Furans	D5837	<100 ppb		
Hydrogen (H2)				
Oxygen & Argon				
Nitrogen (N2)				
Methane (CH4)				
Carbon Monoxide (CO)				
Carbon Dioxide (CO2)				
Ethylene (C2H4)				
Ethane (C2H6)				
Acetylene (C2 H2)				
Total Gas Content				

Comments

Chemical Properties	OK
PCB Content	PCB fluid
Dissolved Gas Content	---

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TECHNICAL FIELD SERVICE DIVISION

Special Projects Group

Client Information

Customer	Toronto Zoo	**Date**	June 14, 1999
File Number	6621	**Tested By**	RPM/ JRK
Location	361A Old Finch Ave., Scarborough, Ontario		
Equipment I.D.	T5		
Substation	North American Pavilion		

Power Transformer -Mechanical

Mechanical Inspections

Description of Inspection	*Status*	*Comments*
Breather & Silica Gel	N/A	
Explosion Vent Gaskets	N/A	
Pressure Relief Device	OK	
Conservator Tank Gaskets	N/A	
Inspection Cover Gaskets	OK	
Main Cover Gaskets	N/A	
Primary Bushing Gaskets	OK	
Primary Bushing Porcelain	OK	
Primary Bushing Connections	OK	
Secondary Bushing Gaskets	OK	
Secondary Bushing Porcelain	OK	
Secondary Bushing Connections	OK	
Secondary Throat Gaskets	OK	
Radiator	OK	
Pressure Gauge	OK	
Gas Relay	N/A	
Oil Level	OK	
Oil Leaks	OK	
Tank Valves	OK	
Oil Temperature Gauge	OK	
Oil Temperature Run/Max	35 | 40°c	
Winding Temperature Gauge	N/A	
Winding Temperature Run/Max	|	
Tap Changer		Unit Locked: Inoperable
Paint Condition	OK	
Pad	OK	
Grounding	OK	
Fan Operation	N/A	
Control Wiring	N/A	
Results Satisfactory	**OK**	

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T.S. P_Trans_Mech

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TECHNICAL FIELD SERVICE DIVISION

Special Projects Group

Client Information

Customer	Toronto Zoo	**Date**	June 14, 1999
File Number	6621	**Tested By**	RPM
Location	361A Old Finch Ave., Scarborough, Ontario		
Equipment I.D.	T5 Secondary		
Substation	North American Pavilion		

Bus Duct

Nameplate Data

Manufacturer	Square D	**Voltage**	600	**Volts**
Type	I-Line	**Current**	1000	**Amps**
Style	3 Phase, 4 Wire	**B.I.L.**		**kVolts**
Cat #	AF-510-23-FES	**Serial #**		

Mechanical Inspections

Description of Inspection	*Status*	*Comments*
Bus Insulation	OK	
Type of Bus Insulation	OK	
Support Insulators	OK	
Interior Clean	OK	Visible Sections Only
Interior Dry	OK	Visible Sections Only
Bus Duct Enclosure	OK	
Bus Duct Enclosure Ventilated	N/A	
Bus Joints Clean & Dry	OK	
Bus Joints Torqued	OK	
Gaskets at Joints	OK	
Grounding	OK	
Enclosure Paint Condition	OK	
Support Structure	OK	

Electrical Tests

Test Description	*ϕA*	*ϕB*	*ϕC*	*N*	*A/B*	*B/C*	*C/A*
Insulation Resistance (MΩ)	1120	1260	900	---	2520	2320	2200

Comments	
Results Satisfactory	OK

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TECHNICAL FIELD SERVICE DIVISION

Special Projects Group

Client Information

Customer	Toronto Zoo	**Date**	June 14, 1999
File Number	6621	**Tested By**	RPM
Location	361A Old Finch Ave., Scar., Ontario		
Equipment I.D.	Main Secondary C.B.		
Substation	North American Pavilion		

Low Voltage Air Circuit Breaker

Nameplate Data

Manufacturer	ITE	**Voltage**	600	**Volts**
Type	K1600	**Frame Rating**	1600	**Amps**
Serial #	98012	**Int. Rating**	65	**kAmps**
Relay Type	OD4 Dashpots Only	**Sensors Ratio**		**Amps**
Rating Plug.		**Limiter Rating**	N/A	**Amps**

Relay Calibration Results

	Settings		ϕA		ϕB		ϕC	
	P/U	**T.D**	**P/U**	**T.D.**	**P/U**	**T.D.**	**P/U**	**T.D.**
Long Time	1000A	Inst.						
Short Time								
Instantaneous								
			P/U	**T.D.**				
Ground Fault								

Mechanical Inspections

Description of Inspection	*Status*	*Comments*
Main & Arcing Contacts	OK	
Arc Chutes	OK	
Phase Barriers	OK	
Bus & Grounding Stabs	OK	
Interlocks	OK	Rack Out Only
Manual Operation	OK	
Electrical Operation	N/A	

Electrical Tests

Test Description	ϕA	ϕB	ϕC	*A/B*	*B/C*	*C/A*
Insulation Resistance (MΩ)	>999	>999	>999	>999	>999	>999
Contact Resistance (μΩ)	25	31	27			
Results Satisfactory	OK					

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Technical Field Service Department

31 Pullman Court, Scarborough, Ontario M1X 1E4. Phone: (416)-298-9977 Fax: (416)-298-2907

Africa Pavilion

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TECHNICAL FIELD SERVICE DIVISION

Special Projects Group

Client Information

Customer	Toronto Zoo	**Date**	June 16, 1999
File Number	6621	**Tested By**	KH
Location	361A Old Finch Ave., Scarborough, Ontario		
Equipment I.D.	Feeder to Indo-Malaya Pavilion		
Substation	Africa Pavilion		

High Voltage Air/Load Break Switch

Nameplate Data

Manufacturer	S&C	**Voltage**	27	**kVolts**
Type	Alduti Indoor	**Current**	600	**Amps**
Style #		**B.I.L.**	150	**kVolts**
Cat #	34063	**Serial #**		

Mechanical Inspections

Description of Inspection	*Status*	*Comments*
Key Interlock	N/A	
Operating Mechanism	OK	
Operating Handle Grounding	N/A	
Grounding Mat	N/A	
Stationary Contact Surfaces	OK	
Moving Contact Surfaces	OK	
Arcing Contact Surfaces	OK	
Contact Alignment	OK	
Arcing Interrupter	OK	
Connector Condition	OK	
Insulator Condition	OK	
Phase Barrier Condition	OK	
Support Structure Condition	OK	

Electrical Tests

Test Description	*ϕA*	*ϕB*	*ϕC*	*A/B*	*B/C*	*C/A*
Insulation Resistance (MΩ)	780	540	755	3420	3280	4080
Contact Resistance (μΩ)	55	57	65			
Arc Interrupter Res.(Ω)	0.7	0.5	0.9			
Results Satisfactory	OK					

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TECHNICAL FIELD SERVICE DIVISION

Special Projects Group

Client Information

Customer	Toronto Zoo	**Date**	June 16, 1999
File Number	6621	**Tested By**	KH
Location	361A Old Finch Ave., Scarborough, Ontario		
Equipment I.D.	Feeder to North America Pavilion		
Substation	Africa Pavilion		

High Voltage Air/Load Break Switch

Nameplate Data

Manufacturer	S&C	**Voltage**	27	**kVolts**
Type	Alduti	**Current**	600	**Amps**
Style #		**B.I.L.**	150	**kVolts**
Cat #	34063	**Serial #**		

Mechanical Inspections

Description of Inspection	*Status*	*Comments*
Key Interlock	N/A	
Operating Mechanism	OK	
Operating Handle Grounding	N/A	
Grounding Mat	N/A	
Stationary Contact Surfaces	OK	
Moving Contact Surfaces	OK	
Arcing Contact Surfaces	OK	
Contact Alignment	OK	
Arcing Interrupter	OK	
Connector Condition	OK	
Insulator Condition	OK	
Phase Barrier Condition	OK	
Support Structure Condition	OK	

Electrical Tests

Test Description	*ϕA*	*ϕB*	*ϕC*	*A/B*	*B/C*	*C/A*
Insulation Resistance (MΩ)	780	540	755	3420	3280	4080
Contact Resistance (μΩ)	38	36	36			
Arc Interrupter Res.(Ω)	0.7	1.4	0.8			
Results Satisfactory	OK					

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TECHNICAL FIELD SERVICE DIVISION

Special Projects Group

Client Information

Customer	Toronto Zoo	**Date**	June 16, 1999
File Number	6621	**Tested By**	KH
Location	361A Old Finch Ave., Scarborough, Ontario		
Equipment I.D.	Africa Paddock Feeder		
Substation	Africa Pavilion		

High Voltage Air/Load Break Switch

Nameplate Data

Manufacturer	S&C	**Voltage**	27	**kVolts**
Type	SM Alduti Indoor	**Current**	600	**Amps**
Style #		**B.I.L.**	150	**kVolts**
Cat #	34563R4-T2	**Serial #**		

Mechanical Inspections

Description of Inspection	*Status*	*Comments*
Key Interlock	OK	
Operating Mechanism	OK	
Operating Handle Grounding	N/A	
Grounding Mat	N/A	
Stationary Contact Surfaces	OK	
Moving Contact Surfaces	OK	
Arcing Contact Surfaces	OK	
Contact Alignment	OK	
Arcing Interrupter	OK	
Connector Condition	OK	
Insulator Condition	OK	
Phase Barrier Condition	OK	
Support Structure Condition	OK	

Electrical Tests

Test Description	*ϕA*	*ϕB*	*ϕC*	*A/B*	*B/C*	*C/A*
Insulation Resistance (MΩ)	780	540	755	3420	3280	4080
Contact Resistance (μΩ)	50	50	48			
Arc Interrupter Res.(Ω)	0.6	0.5	0.5			
Results Satisfactory	OK					

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TECHNICAL FIELD SERVICE DIVISION

Special Projects Group

Client Information

Customer	Toronto Zoo	**Date**	June 16, 1999
File Number	6621	**Tested By**	KH
Location	361A Old Finch Ave., Scarborough, Ontario		
Equipment I.D.	Paddock Feeders		
Substation	Africa Pavilion		

High Voltage Power Fuse

Fuse Holder Nameplate Data				
Manufacturer	S&C	**Voltage**	27.6	**kVolt**
Type	SM-5	**Current**	300E	**Amps**
Style/Cat #	86644R1	**Serial #**		

Fuse Link Nameplate Data			
Type	SM-5	**TCC**	
Style/Cat #		**Amps**	

Mechanical Inspections

Description of Inspection	*Status*	*Comments*
Operating Mechanism	OK	
Contact Surfaces	OK	
Contact Penetration	OK	
Contact Alignment	OK	
Fuse Barrel	OK	
Connector Condition	OK	
Insulator Condition	OK	
Phase Barrier Condition	OK	
Support Structure Condition	OK	
Spare Fuses	POOR	No Spares in Cell

Electrical Tests

Test Description	*ϕA*	*ϕB*	*ϕC*	*A/B*	*B/C*	*C/A*
Insulation Resistance (MΩ)						
Contact Resistance (μΩ)	1030	960	1030			
Results Satisfactory	Fair. Spares Required.					

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TECHNICAL FIELD SERVICE DIVISION

Special Projects Group

Client Information

Customer	Toronto Zoo	**Date**	June 16, 1999
File Number	6621	**Tested By**	KH/ RPM
Location	361A Old Finch Ave., Scarborough, Ontario		
Equipment I.D.	McDonald Savannah (Africa Paddock Fed)		

Pad-Mounted Distribution Transformer

Transformer Nameplate Data

Manufacturer	Cam Tran		**Year Built**	1997		
Type	ONAN		**Serial #**	97DC231201		
Neutral	Solid		**Liquid Type/Vol**	Oil	1436	**Litres**
Rating	500	**kVA**	**Total Weight**	3492		**Kg**
Impedance	5.4	**%**	**Primary Voltage**	27.6/ 16		**KVolt**
Phase(s)	3	**ϕ**	**Secondary Voltage**	208/ 120		**Volt**
Frequency	60	**Hz**	**BIL**	125		**kVolt**
Insulation Resistance (MΩ)	>505,000					

Oil Analysis

Laboratory Tests

Type of Test	ASTM No.	Acceptable Limits	Test Results
			1999
Dielectric Breakdown	**D877**	**30 kV Min.**	44.4
Neutralization Number	**D974**	**0.05 Max. Mg Koh/G**	0.027
Interfacial Tension	**D971**	**32 Dynes/ Cm Min.**	40.1
Specific Gravity	**D1298**	**0.84 - 0.91**	0.867
Colour	**D1500**	**≤3.5 Max.**	<0.5
Visual Condition	**D1524**	**Clear**	Clear

Observations & Comments

Comments:	
Results Satisfactory:	OK

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TECHNICAL FIELD SERVICE DIVISION

Special Projects Group

Client Information

Customer	Toronto Zoo	**Date**	June 16, 1999
File Number	6621	**Tested By**	KH
Location	361A Old Finch Ave., Scarborough, Ontario		
Equipment I.D.	Padmount to Africa Sub. 3 phases; to T10 3 phases		

Pad-Mounted Distribution Transformer

Transformer Nameplate Data

Manufacturer	CARTE		**Year Built**	1996	
Type	ONAN		**Serial #**	2B301-001	
Neutral	Solid		**Liquid Type/Vol**	Oil 1023	**Litres**
Rating	225	**kVA**	**Total Weight**	2227	**Lbs.**
Impedance	4.34	**%**	**Primary Voltage**	27.6/ 16	**kVolt**
Phase(s)	3	**ϕ**	**Secondary Voltage**	208/ 120	**Volt**
Frequency	60	**Hz**	**BIL**	125	**kVolt**
Insulation Resistance (MΩ)	435,000				

Oil Analysis

Laboratory Tests

Type of Test	ASTM No.	Acceptable Limits	Test Results
			1999
Dielectric Breakdown	**D877**	**30 kV Min.**	32.0
Neutralization Number	**D974**	**0.05 Max. Mg Koh/G**	0.013
Interfacial Tension	**D971**	**32 Dynes/ Cm Min.**	38.6
Specific Gravity	**D1298**	**0.84 - 0.91**	0.889
Colour	**D1500**	**≤3.5 Max.**	0.5
Visual Condition	**D1524**	**Clear**	Clear

Observations & Comments

Comments:	
Results Satisfactory:	OK

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