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Résumé de l'article

Les travaux d'infrastructure publique et les organismes qui les construisent ou qui soumissionnent pour leur construction sont importants dans l'histoire de la standardisation pour plusieurs raisons. La magnitude, la signification et l'ubiquité de tels travaux rendent la pratique de la standardisation importante pour et en elle-même. La rigueur employée dans la mise en application de ces standards aux contacteurs et aux fournisseurs, tout en agissant sur l'amélioration des pratiques industrielles, possède aussi l'effet secondaire de favoriser les entreprises qui les maîtrisent et qui peuvent s'y conformer. Les organisations publiques ne disposent pas seulement des contrats pour mettre en oeuvre leurs idées sur la standardisation mais encore de la réglementation. Les standards des travaux publics contribuent à définir les relations de l'État avec l'espace géographique à l'intérieur duquel il gouverne. Ces enjeux seront explorés à partir de quatre cas exemplaires en Ontario : les travaux routiers et de bâtiments, la santé publique et la réglementation pour les travaux d'aqueduc, la Commission Hydroélectrique de l'Ontario et, finalement, la ville de Toronto.

Raising Standards: Public Works and Industrial Practice in Interwar Ontario

JAMES P. HULL

Abstract

Public works and the bodies which build them or contract for their building are important to the history of standards for a variety of reasons. The sheer size, significance and ubiquity of such works, make standards practice important in and of itself. The rigour used in enforcing those standards on contractors and suppliers, while exerting a force for the improvement of industrial practice, also had the secondary effect of favouring those firms which were familiar with and could meet such standards. Public agencies had not just contractual means to enforce their ideas about standards but often regulatory ones as well. Public works standards helped define the state's relationship with the geographical space in which it acted. These issues will be explored using four case studies from Ontario: public roads and buildings, public health regulation and standards for municipal water works, the Hydro-Electric Power Commission of Ontario and finally the City of Toronto.

Résumé

Les travaux d'infrastructure publique et les organismes qui les construisent ou qui soumissionnent pour leur construction sont importants dans l'histoire de la standardisation pour plusieurs raisons. La magnitude, la signification et l'ubiquité de tels travaux rendent la pratique de la standardisation importante pour et en elle-même. La rigueur employée dans la mise en application de ces standards aux contacteurs et aux fournisseurs, tout en agissant sur l'amélioration des pratiques industrielles, possède aussi l'effet secondaire de favoriser les entreprises qui les maîtrisent et qui peuvent s'y conformer. Les organisations publiques ne disposent pas seulement des contrats pour mettre en œuvre leurs idées sur la standardisation mais encore de la réglementation. Les standards des travaux publics contribuent à définir les relations de l'État avec l'espace géographique à l'intérieur duquel il gouverne. Ces enjeux seront explorés à partir de quatre cas exemplaires en Ontario : les travaux routiers et de bâtiments, la santé publique et la réglementation pour les travaux d'aqueduc, la Commission Hydroélectrique de l'Ontario et, finalement, la ville de Toronto.

INTRODUCTION

Public works and the bodies which build them or contract for their building are important to the history of standards for a variety of reasons. Most obviously the sheer size, significance and ubiquity of such works, make standards practice pertaining to them important in and of itself. The rigour used in enforcing those standards and imposing them on contractors and suppliers had an influence beyond the public agencies themselves. While exerting a force for the improvement of industrial practice (that is, making it more exact and standard) this also had the secondary effect of favouring those firms that could meet and were familiar with such standards. Public agencies often had not just contractual but also regulatory means to enforce, or at least negotiate from strength, their ideas about standards. Public works standards, with their hegemonic mix of dispersed consensus and hierarchical coercion, helped define the state's relationships with the various parts of the geographic space in which it acted. Following a discussion of the recent historiography of standards and a brief overview of the early history of standards in Canada, these issues will be explored using four case studies from Ontario: public roads and buildings, public health regulation and standards for municipal water works, the Hydro-Electric Power Commission of Ontario and finally the City of Toronto.

STANDARDS, MEASUREMENT, AND THE RATIONALITY OF SCIENCE

A standard is "a precise statement of a set of requirements to be satisfied by a material, product, system, or service that also indicates the procedures for determining whether each of the requirements is satisfied."[1] Although there is a pre-history of standards, involving military production, railway gauge and excise taxation, modern standards-promulgating bodies emerged around 1900.[2] They variously took the form of stand-alone organizations such as the American Society for Testing Materials; joint projects of technical or trade associations, such as the British Engineering Standards Association; or committees of professional associations of engineers, such as the American Society of Mechanical Engineers Boiler Code Committee. Not coincidentally, this is the same period in which capstone bodies of national research with strong mandates in testing methods and calculating physical constants also emerged, led by the German *Physikalisch-Technische Reichsanstalt* and followed soon by the National Physical Laboratory in Britain and the American National Bureau of Standards.

The need for such organizations arose from a number of factors. As the second industrial revolution matured, manufacturing techniques became more precise and more exact though unevenly so throughout the economies of various countries. Large multi-unit firms sought first to standardize their own operations and then gain the advantage of in-house specifications being recognized as industry standards. As the volume of transactions in the economy skyrocketed, managers sought to control transaction costs either by internalizing them or through effective mechanisms to obviate disputes between buyers and sellers.[3]

Amy Slaton's recent work on concrete and other industrial standards has shown how they order and control work processes.[4] Standards and specification both simplify and order complexity and change loci of skill and control in systems of production, distribution and consumption. Standards, at the work site, were part of engineers' exercise of intellectual authority, hand in hand with managerial authority. They empowered professional workers, relative to skilled craftspeople, and in their formulation brought users into the process of production. They were as well, part of a broader shift in information management in turn of the century business to more written and quantified information.

The economics of a technical programme of uniformity, standardization or interchangeability may be far from obvious. Ken Alder has pointed out that, for the state, a decision to commit, or not, to such a programme can be driven to a desire to address wider objectives.[5] For governments, standards bodies were part of the secondary organization of industry that enabled capital to pursue freedom and security of enterprise short of the politically problematic level of monopoly. Standards as well were a means to regulate industry, both on its own behalf, to assist in mitigating intra-class disputes and to provide at least the appearance of democratic control over new technologies embedded within the framework of capitalist exchange relations.[6]

Historians of engineering have long noted the significance of standards work for developing engineering professionalism.[7] Engineers, increasingly in proximate charge of production in manufacturing facilities, sought to communicate with one and other—and indeed to dominate if not monopolize the discourse over production—in the manner to which their training at *Technische Hochshulen*, red brick universities and land grant colleges had accustomed them. For those controlling standards, they were a triumph of new scientific rationality over sloppy and wasteful traditional practices. That standards did in fact achieve certain measurable economic goals cannot be disputed and at least some of those benefits were widely distributed, though others were captured at various points. Scholars have however recently begun to deconstruct the claim of rationality, noting the negotiated nature of the knowledge claims which are standards and the hegemonic function of those claims.[8] Stuart Shapiro has noted that standards are ways of controlling complexity and constraining choice and, building in part on the work of Bruno Latour, shown how they are part of creating aspects of the world of the laboratory outside of the laboratory.[9]

Even so-called physical constants, seemingly built in to the fabric of the universe, are in the end human constructs and the outcome of negotiation.[10] The precision measurements at the heart of standards practices are, as Alexandre Mallard has noted, "never completely true, nor completely conventional, but precisely 'conventionally true'. This is a subtle way of articulating the natural [...] and the social [...] character of precise measurement."[11] Even the transference of ideas about precision measurement between the scientific and engineering realms faces challenges as much or more cultural as technical.[12] Finally, claims that precision measurement marks a shift from fallible, human, sensory judgment to exact, objective, instrumental truth are inherently flawed since, as Otto Sibum has pointed out, measurers are still using their bodies when using instruments.[13]

ORIGINS OF STANDARDS IN CANADA

The government of Alexander Mackenzie, in the 1870s, legislated standard weights and measures, an authority given to the Dominion government under the British North America Act. In doing so, the dour stonemason only continued a pre-Confederation practice of using metrological initiatives to establish central authority over localism. As Bruce Curtis argues, "metrological reform projects typically involve assertions of state sovereignty, yield bodies of knowledge that typically increase the capacity of state agencies to act at a distance, and provide forms of leverage over local practices."[14] More focused actions addressed the legislating of standards for gas, electricity and petroleum and such agricultural products as eggs, cream and wheat. The adoption of "railway time" by municipal authorities implemented temporal standardization.[15]

Canadian technical professionals collaborated with their counterparts to the south in US-based bodies to develop standards used throughout the continent. Sandford Fleming's work on standard time—done in part as chair of the American Society of Civil Engineers Special Committee on Uniform Standard Time—is famous.[16] Not so is the work of W. H. Randall, Superintendent of Maintenance for the City of Toronto's Water Department, who sat on the Committee on Revision of Standard Specifications for Cast Iron Pipe and Specials of the American Water Works Association.[17] Other Canadians quietly worked to help establish standard methods for everything from examination of milk, to numbering railway bridges, to testing gas tractors.[18] Among the earliest members of the American Society for Testing Materials (ASTM) were Phelps Johnsen, Manager, Dominion Bridge; Gustave Giroux, Inspector of Materials for the Canadian Pacific Railway; Henry Robertson Lordly, Engineer-in-Charge of the Lachine Canal; and George E. Perley, a cement expert for the Dominion Department of Public Works.[19]

Such work while significant was exceptional. Specifications writing, contracting and the overseeing of contracts remained a blend of excruciating detail and vague generalities. The reputation of brands and of individual engineers remained paramount.[20] In May and again in June of 1911 the well-regarded technical journal *The Canadian Engineer* felt moved to editorialize on what it saw as the poor state of contract specification in Canada. An editorial on "Manufacturers' Specifications" pointed out the need for more detailed specifications in contract bidding.[21] The next month the editors took aim at specifications for steel rails, criticizing the inadequacies of testing procedures used in specifications for re-rolled rails.[22] An instance of the sort of dispute that all too frequently arose comes from the City of Toronto in 1913. A contractor declined to execute a contract due to differences of opinion regarding the interpretation of a clause in the specifications relating to the restoration of the pavement. For his part the Commissioner of Works insisted that those specifications were the standard specifications of the Department.[23]

Change was coming. Engineering students at Canadian universities were learning new contracting practices based in part on standard specifications.[24] They were trained to use scientific instruments, to measure with precision industrial phenomenon and to report accurately in reference to standards.[25] With the professors they conducted tests on construction materials and industrial machinery in the different universities' laboratories, like the testing, cement, electrical or mechanical laboratories, during the last years of their program at Toronto's Faculty of Applied Science and Engineering. Trade associations including the Canadian Electrical Association and the Canadian Cement and Concrete Association had their own standards committees. The country's principal engineering society, the Canadian Society of Civil Engineers (CSCE), had studied the issue of standards since the beginning of the twentieth century and chose to proceed with its usual caution. It did, though, by 1912 arrive at an important new standard for steel railway bridges.[26] During World War One after some prodding from the UK and with some small support from the Federal Department of Trade and Commerce, a group of Montreal engineers organized what is today the Canadian Standards Association (CSA). As the Canadian Engineering Standards Association (CESA) that body would have a major role to play in providing a mechanism for the writing of standard specifications which then found use in contracts as well as regulations across the country.[27]

ROADS AND BUILDINGS

Historians of technology have noted the significance of state armouries and of the railways in advancing manufacturing practice during the nineteenth century. Both types of institutions were in the forefront of higher precision, more standardized, manufacturing techniques and such techniques migrated thence out into general industry through a web of contractual relationships and the movement of skilled personnel.[28] An examination of Ontario's public works infrastructure will show that governmental agencies occupied a similar position with respect to industrial practice in the first half of the twentieth century.

The Department of Public Works had the responsibility for drawing up contract specification for the large number of public buildings constructed across the province for the Ontario government. Prior to the First World War, contracts for the construction of such buildings and oversight of them seems in general not to have been in advance of typical contracting practice in the province. A notable exception related to steam power. The public interest in not being injured by boiler explosions had early drawn both governments and engineering bodies into the study and regulation of this quintessential first industrial revolution technology.[29] In Ontario, legislation required boilers to be subject to the approval of a provincial inspectorate, part of the Department of Public Works. Thus boilers and associated works in public buildings came doubly under the control of the Department and represented an early foray by it into the world of modern technical standards. Initially, the Department relied heavily on the use of patented devices and the claims and reputation of makers. But this changed in the years after the turn of the century. In 1905 the Manager of the Canadian Steam Boiler Equipment Company Ltd. informed the Minister of Public Works of the firm's readiness to make an official evaporated test of coal with a Ministry Inspector present.[30] Inspectors, reporting to the Chief Architect of the Department, on boilers installed everywhere from the North Bay Registry Office to the Haileybury Court House gave painstaking accounts of deviations from the Department's specifications and follow-up reports of mandated changes made by the contractors.[31]

Similarly, the Province's Engineer of Highways, had the legislative lash and fiscal carrot with which to encourage local construction of roads and bridges to his specifications.[32] Local authorities wishing provincial monies for such works had to build them in accordance with those specifications. In 1911, University of Toronto engineering professor Clarence Richard Young wrote to W. A. McLean, then Provincial Engineer of Highways and later Deputy Minister, praising the latter's specifications for steel highway bridges as "the best highway bridge specifications yet issued."[33] The 1912 Highway Improvement Act explicitly stated that "[c]onstruction is to be guided by the last revised 'Principles of Roadmaking' issued by the Provincial Engineer of Highways except as more specifically stated in these regulations."[34]

An April 1919 contract for a Students' Residence at the Ontario Agricultural College in Guelph nicely captures a changing standards regime.[35] In part, the contract relies on brand and suppliers' names to indicate standards, e.g. "treads shall be finished with Canada Mastic Fireproof Sanitary flooring, as supplied by the Canada Floors Limited [...] or equal thereto." In part, reference is made to trade standards for metal "No. 16 gauge expanded metal" or "No. 28 galvanized iron." But as well the Department wrote its own technical specifications, including tests, for drains and connections. Finally, the contract portentously if inaccurately, mandated the use of a published consensus standard, cement for the building having to "comply with the test requirements of the CANADIAN [sic] Association of Civil Engineers."

Over the next twenty years, while this same mix of old, new and borrowed would continue to appear in the Department's contracts, trends towards more exacting specifications, greater capacity to write and supervise such specifications and use of published consensus standards become increasingly evident. Contract specifications for the Whitney Block (part of the Ontario Parliament Buildings), over a number of years from the late 1920s to early 1930s, offer examples of these.[36] Some use of brand names remained the easiest way to give specifications, though usually for relatively minor items. Thus the contract makes reference to "Belleville Hardware Catalogue No. 4" and "No. 1026 Peterboro Cat. Pattern latches." At the start of the project, 1925 specifications for paint required the use of " 'Superior Graphite Paint' manufactured by the Dominion Paint Works, Walkerville, or some other paint which in the opinion of the Architects is equal to it in quality." A year later, specifications for the building's interior finishings required that samples of paints, oils, varnishes, etc. "shall first be submitted to the Architect [...] with a certified analysis." By 1932 when specifications for a provincial laboratory in the building were drawn up, the wooden tops of benches, fume cabinets and the like "shall be finished with a special acid proof black finish, the formula of which will be supplied by the Department." The electrical work for the building had to meet Ontario Hydro's rules and the cement had to pass Canadian Engineering Standards Association test requirements. Reinforcing and structural steel had to meet ASTM standards, with the contractor bearing the cost of making such tests as necessary to demonstrate adherence to those physical and chemical specifications. The Department however gave details for its own specifications for working with the metal, for instance tolerances for punches in riveting.

Similar trends are apparent in the Department of Public Highways. Specifications for construction on Niagara Boulevard in Fort Erie in 1937 made frequent reference to ASTM standards. For cement, the Department gave some of its own standard specifications, e.g. for screening of coarse aggregate, listed tests in some detail and then added "in other respects [...] shall be in accordance with" the ASTM standard. The contractor had to make tests at a laboratory other than his own with a cost of three cents per barrel tested, the most to be charged under the contract. In giving specifications for asphalt, the Department made reference to technical information appearing in the *Journal of the American Chemical Society* and for pipe, again it was ASTM standards.[37] Impressionistically, it seems that Highways was rather more committed to US standards than was Public Works. If so, it is especially interesting to note a request from the Vice President and General Manager of Dominion Foundries and Steel to a Highways Bridge Engineer at the depth of the Great Depression imploring the Department to specify only Canadian made steel in all its contracts.[38]

By the end of the 1930s, the Department of Public Works had entirely routinized its use of technical standards. The contract for the construction of the St. Thomas Hospital stated that "[u]nless otherwise expressly provided in the specifications all goods and materials supplied shall conform to the specifications of the [CESA]." If such goods or materials were not of Canadian origin then the "recognized standards association of that country shall apply."[39] Court houses and highway bridges offered visible evidence of the presence of the Ontario state in places near and far from Queen's Park. In bringing the negotiated consensus standards framed in engineering committees in Philadelphia, New York and Montreal to the buildings and roads of Ontario's towns and townships these mundane contract specifications are as well "vivid historical markers of social authority."[40]

Recently, the linking of seven deaths in Walkerton, Ontario, to improper or inadequate water testing has provided a rare instance of the claims and practices of standards setters and users being brought into public dispute. From the nineteenth century, the Public Health Act in Ontario gave the province's Board of Health powers to inspect sewerage plants and oversee water analyses.[41] This was supplemented by a 5 October 1914 Order-in-Council requiring that the material used in municipal water works must be those of the CSCE or some similar body. Municipalities could set more stringent specifications but those would have to be on record with the Board. This helped to extend the reach of the provincial Leviathan,[42] as well as that of standards-writing engineers, out into the towns of the province in much the same way as the highway legislation. To see this in action we may look at the career of engineer Frederick Alfred Dallyn.

Born in Hamilton in 1886 Dallyn received his B.A.Sc. from Toronto in 1910.[43] Three years later he became Ontario's first Provincial Sanitary Engineer. As such it fell to him to approve local plans for water supply, water works systems, water purification plants and the like. However, even while in this position, Dallyn also served as a consultant to local authorities on those very works. Matters came to a head in 1926 when Dallyn was forced out of his government position in a very public dispute over his receipt of fees for services beyond his salary in the design and construction of the East York sewage plant. The litigious Mr. Dallyn later became embroiled in separate legal suits with his sometime partner D. H. Fleming and with another prominent consulting engineer G. G. Naismith over the Kitchener sewage plant. These legal travails notwithstanding, for thirty years villages, towns and cities from one end of the province to the other entrusted Dallyn with the task of writing specifications for their public works and then overseeing the contracts for them. His service as Chairman of the Committee on Sewage Disposal and Sanitation for the American Society of Municipal Improvement further attests to his competence and reputation. His work illustrated the issues which a working engineer involved with this class of public works faced in the area of technical standards and how such standards informed the shape of those works.

Dallyn made routine use of standards in writing his contracts. He drew upon both Canadian and US standards from a range of standards-promulgating bodies, most prominently the CESA and ASTM, and seems to have kept up-to-date with the latest standards. Thus a 1928 call for tenders for the Town of Blind River's pumphouses insists that cement be to the CESA's 1927 specifications, while the May, 1941 contract for the Town of Bala's sewers demands adherence to the 1940 version of that standard. That he reevaluated specifications critically is suggested by his change, in 1929, from ASTM to CESA standards for structural steel. A contract he supervised for the Village of Glencoe's water supply in 1928 required an American contractor to meet both ASTM and CESA specifications, indicating to us that standards might provide an interesting insight into the mechanism of continental economic integration. Standards routinely provided a means for efficient communication between Dallyn and contractors. In a bid to supply a crane for the City of Oshawa's new filtration plant, W. J. Westway Company promised the type of crane specified in Dallyn's contract "with necessary 35 pounds A.S.C.E. crane Running Rail."[44]

Where necessary, Dallyn combined the use of consensus standards with his own detailed specifications. The cement mortar for Grimsby's sewers had be "composed of one part of Portland Cement to two parts of approved sand." The organic impurities in sand must be tested per ASTM test but Dallyn gave his own table for grading coarse aggregate. The sand itself was "Standard Ottawa sand" a trade standard.[45] Those wishing to supply sewer pipe for the Town of Blind River could just use the ASTM specification if they wished to supply concrete pipe. But for vitrified pipe Dallyn listed his requirements for such characteristics as inside diameter, thickness, depth of socket, annular space and weight per foot.

Here Dallyn pursued his own agenda. When the Commissioner of Works for York Township asked Dallyn about the specification of concrete or vitrified tile pipe, the latter took the opportunity to disparage the recommendations of his former employer, the Department of Health, calling their views on concrete too conservative. He went on to explain "the reason why cement concrete pipe has been increasing in use, I think, is to be associated with the fact that the specifications of the [ASTM] and the inspection service of our various manufacturers has established the industry on a proper basis."[46] When the Town Engineer of Pembroke anxiously inquired whether it was all right to use concrete pipes as "vitrified clay people [!] claim the pipe will disintegrate in a few years," Dallyn assured him that "provided the pipe is manufactured by an expieranced [sic] manufacturer and according to standard specifications the [sic] is no objection to its use."[47] Dallyn was in fact no concrete expert and he knew it. He used the services of Ontario Hydro's laboratory to test sand and crushed rock for him and a seconded Hydro engineer acted as his concrete inspector for the Oshawa sewage works.[48]

Standardization was not always possible. Historians have noted the crucial role of standards for fire fighting equipment in promoting interest in standards. Watching one's downtown burn to the ground whilst fire companies from nearby communities stood helpless, unable to couple their hoses to the city's hydrants, made a powerful impression. In the Proposal for Bids for Hydrants and Valves for the Blind River pumphouses, Dallyn specified that hose nozzle connections "shall be threaded with the same thread as the Carpenter-Hixon Mill" has adopted. This conformance to nearby connections remained typical in contracts until the province finally moved to standardize such equipment in the 1950s as a Cold War civil defence measure.

His dozen years as Provincial Sanitary Engineer made Dallyn well aware of the regulatory environment within which public works were built. The Board of Health's printed form, which applicants for construction of municipal water works submitted, helpfully listed CSCE standard weights of cast-iron pipe. The Institute of Public Health in London, Ontario, used by Dallyn for water analysis, stated on its form that the work was done according to the American Public Health Association's standard methods. Dallyn's contracts insisted that electrical work needed to meet Ontario Hydro regulation. This was not simply pro forma. The supplier of the pump for Stoney Creek's water works, the Smart-Turner Company Ltd of Hamilton, wrote to Dallyn to assure him that "we have been speaking to Mr. Caster of [Hydro] and have checked the characteristics of the electric circuit, and have their approval of the starter we are supplying."[49] When the company building a chimney for the Sudbury water works indicated they were intending to use their own brand of lightning rod Dallyn immediately vetoed this noting the requirement to conform to the Ontario Lightning Rod Act.

The Board of Health's form also listed the requirements of the Canadian Fire Underwriters' Association. The Underwriters, with their own views of adequate standards for municipal water supplies, inspected and issued reports on municipal waterworks. Dallyn dutifully specified, as in the contract for the supply of electric current to the Grimsby water works by the Hamilton Cataract Power, Light and Traction Company, Ltd, that "the motors, transformers [...] and all wiring and appliances within the buildings [...] shall be installed in a manner satisfactory to the Canadian Board of Fire Underwriters."[50] But privately he was unimpressed. As he told the Public Utilities Commission of Ingersoll in an 18 March 1929 letter, "The criticisms [...] though oft repeated in the Canadian Fire Underwriters' Association reports, do not appear to have greatly influenced the insurance rates."[51]

Dallyn's contracts, like those of other engineers of the period, in lieu of detailed specifications made use of reference to brand name products. These ranged from Dr. Angus Smith's patent composition, with which to coat castings for Grimsby's sewers to General Electric or Westinghouse motors for the pumps of the Midland Public Utilities Commission. Usually, though not always, some phrase such as "or equivalent" accompanied such a brand name specification to prevent objections from other manufacturers. This could itself provoke complaints. W. S. Leslie of A. C. Leslie & Company of Montreal, wrote to Dallyn urging the specification of their brand of Copper Bearing Sheets and regretting the allowance of substitutes.[52] Leslie's "Queen's Head" sheets were in fact well regarded and appear in the contract specifications of other engineers. By this time however, it was getting rather late in the day for such proprietary exclusivity to be written into public works contracts. Many firms wrote or sent catalogues or other promotional material to Dallyn hoping to have their products used in the works he oversaw. Many of them drew attention to their adherence to recognized standards. The National Iron Corporation of Toronto, wanting to supply cast iron pipe for a project in Colborne noted that their specifications were based on the US government's for pipe and had the approval of Underwriter's Laboratories. A promotional sheet of T. McAvity & Sons, a Canadian maker of brass and iron products such as valves, noted that their chart of fittings gave ASME dimensions while their boiler mountings conformed to Canadian Interprovincial Standards. Lord and Burham Company Ltd of St. Catharine's, in their specifications for a sludge bed glass-over, promised all steel to American Institute of Steel Construction specifications.[53]

Dallyn's career allows us to see at a detailed level how standards migrated out into the countryside. Among the most striking features is how noticeable by its absence was the slightest resistance from local interests, though particular details of contract specification, tendering and execution could engender dispute. His career reminds us as well that the state acted only through agents. Not necessarily government employees, such agents, in this case engineers, had considerable latitude in their actions and could pursue ambitions of their own.

ONTARIO HYDRO

Although founded in the early 20th century as a result of pressures from small and medium sized businesses and urban areas seeking low-cost electricity, the Hydro-Electric Power Commission of Ontario became a significant force for reinforcing Toronto's control over its provincial hinterland.[54] It also became the largest single electrical utility in the world, its generating and transmission infrastructure forming a vivid and vital part of the landscape of Canada's industrial heartland. Together the dams, generators, pylons, lines and transformers were public works of impressive scale and scope. Building, maintaining and upgrading that infrastructure put Ontario Hydro's engineers in the forefront of this key technology of the second industrial revolution and made Hydro a key player in the development of technical standards in Canada.[55]

Hailed as the greatest engineering project in the world since the completion of the Panama Canal, Hydro's development of its own generating capacity at Niagara Falls propelled the utility not just into the forefront of power generation but also of standards usage. Built during and just after the Great War, the Queenston-Chippawa power project was by far the largest public work in the country. Contracts for the generating equipment at the Falls show Hydro engineers to be well versed in the use of standards. The US standard (i.e. Sellers) screw thread is specified for screws, nuts and bolts; penstock efficiencies were measured to ASME standards and the "Standard Code for Testing Hydraulic Turbines," adopted only a year earlier by the Machinery Building Society, used.[56] Hydro engineer Richard Hearn (who would eventually head the utility) championed the use at Niagara of the new method of gauging velocity of water flow developed by Norman R. Gibson. He later used his position as chair of the Hydraulic Power Committee of the National Electric Light Association (NELA) to promote Gibson's device as a North American standard at a time when a variety of trade and technical associations were attempting to agree on a new methodology to test hydraulic devices.[57]

It was however in the area of concrete standards that Hydro engineers truly broke new ground. The cost of the Niagara Falls development, borne by Ontario's taxpayers, presented the Ontario government, wrangling with private power interests, with a formidable political issue. Hydro civil engineers reasoned that if close control over the quality of concrete being poured at the project could be assured, the volume of material, and thus costs, could significantly be reduced without compromising safety. Led by Roderick B. Young, Hydro developed innovative new methods, far in advance of prevailing industry practices, to do just that. This involved writing their own manual for concrete testing, putting on-site field laboratories and inspectors in the plant of cement suppliers and backing it all up with further checks as well as a research programme in the Commission's Toronto laboratory.[58] Young's work, which was in advance of even the National

Bureau of Standards, influenced concrete usage far beyond the Niagara peninsula. Over the next quarter century he variously led concrete standards writing committees for ASTM, which awarded him a medal, the American Concrete Institute, of which he was a Director, and the CESA.

Ontario Hydro's transmission lines carried more than electrical power. They brought social and economic change to the province and highly advanced standard and specification practice to the Commission's contractors and suppliers.[59] Hydro both developed its own tests and specifications and used those of a range of external bodies. Tests on galvanizing for steel used in transmission towers in a 1927 specification capture quality control in transition. A copper sulphate test was a closely specified chemical test with directions for preparation of a standard solution and a testing methodology. A hammer test was a physical test which in essence involved hitting a sample with a hammer and seeing if the coating flaked off. A dozen years later, however, steel specifications told of Hydro's requirements for recording pyrometers in the manufacturer's own annealing furnace. Bidders on Hydro contracts had to know and be prepared to work to the standards of ASTM, AIEE, CESA, NELA and others. Revisions to Hydro's specifications involved the integration of the most recent revisions to consensus standards from those bodies. The deep understanding by the Commission's engineers of how standards could or could not work in practice is captured in suggested changes to material specifications for turbines made by Otto Holden, Chief Hydraulic Engineer of Hydro's Test and Inspection Department. Holden suggested the "inclusion of clauses [...] which will serve to eliminate disputes between the inspectors and manufacturers." He felt the use of CESA instead of ASTM specifications would "eliminate criticism from Canadian manufacturers." A changed specification for bronze brushings and sleeves would bring it "in line with suggestions made by the S. Morgan Smith-Inglis Company at the time the Ragged Rapids turbines were manufactured and is the same material as is used by the Dominion Engineering Works" under a different designation. Holden wanted welding only by the electric metallic arc process unless with specific permission, and to Hydro's own specification with shafts and forging to a CESA specification but with additions noted.

It was one thing to write specifications and quite another to have them carried out. As Shapiro observes, "[t]he formulation and use of technological standards of practice are not disjointed activities."[60] Hydro's approach to overseeing its contracts further served to inculcate advanced practice in the firms with which it dealt. Hydro sent out gauges for the builder of its turbines to use and demanded test coupons attached to large castings.[61] The earliest Hydro specifications for transformers demanded tests of materials and gave the Commission's engineer full power to observe and approve such tests. By the mid-1920s specifications included limits on the costs of such tests which could be included in a contract bid. Hydro, while tough, was not unrealistic. A 1939 memo from W. P. Dobson, Chief Testing Engineer and later Director of Research, to A. E. Davison of the Transmission Section discussing revisions to Hydro's 1927 general specifications for steel transmission towers noted the need to modify a clause not permitting plugging or welding of mispunched holes as it "is not readily enforceable."

Correspondence between Hydro and the Packard Electric Company, one of Hydro's most frequent suppliers of major equipment such as transformers, shows both the closeness of oversight by Hydro and the degree to which standards and specifications formed part of a many-sided exchange of technical information.[62] This involved not just Hydro and Packard—itself a highly sophisticated firm in its use of technical standards—but also suppliers of ancillary or complementary equipment. Hydro passed along data from the latter to Packard and worked out the details of conformity between Packard's own testing protocol and Hydro's, backed up by the Commission's greater laboratory resources.[63] This further suggests that Slaton and Abbate's points regarding the hierarchical quality of standards and the standards' role in drawing users, as well as the producers themselves, into production are, if not contradictory, at least in some tension.[64] There is a dynamic, perhaps dialectical, relationship between widely dispersed usage of and participation in the formulation of standards and the authoritative, centralized promulgation of them.

CITY OF TORONTO

A Westinghouse engineer in Peterborough observed that "the most strenuous" contract specifications which the firm had to deal with in Canada were those of Ontario Hydro and the City of Toronto.[65] The province's largest municipality had an important indirect influence on construction and manufacturing practice through its building code, sometimes a matter of intense contention. This resulted in a spectacular public uproar shortly before World War One over the functions of the Chief Architect's office relating, in part, to standards for reinforced concrete in construction work.[66] More directly, the city wrote standards for, constructed or contracted for the construction of, and maintained its own public works infrastructure of roads, sewers, waterworks and the like.

The city developed its own specifications early and often. Even before World War One city tenders for lubricating oil specified flash tests at 500 and 700 degrees and the Works Department had its own electrical testing kit.[67] Tenders for asphalt were evaluated in terms of the city's own specifications including percentage of bitumen and, by the 1920s, these were used for process control in the city's own asphalt plant.[68] It had its own test bar for bronze purchased for valves, used an ASME standard formula to design a Venturi meter to monitor water flow, provided patterns, core boxes, gauges and samples for those making equipment for the Works Department, specified US standard screw thread and pipe dimensions and even standardized its own terminology for "culverts," "bridges" and the like.[69] The Toronto standard for manhole tops found use beyond the city's boundaries.[70] Contract specification and supervision were backed up by an extensive programme of data-gathering and by a Laboratory and Testing Branch within the Department of Works.[71] The Branch prepared specifications, inspected materials at the manufacturers' plants and conducted physical and chemical tests on a wide variety of materials. When necessary, the city sought the expertise and facilities of the University of Toronto to determine whether equipment purchased met recognized standards.[72]

The practice of the Toronto Department of Works, under Commissioner R. C. Harris, with respect to consensus standards seems to have matured with particular rapidity in the second half of the 1930s. This can be seen in comparing specifications used in the Victoria Park water works extension in 1935–36 and the Ashbridge's Bay Sewage Treatment plant five years later. Interestingly enough, this greater application of state-of-the-art engineering methods came at a time when, in other contexts, voices called for a return to less technology-intensive methods of public works construction in the interests of higher employment during the Great Depression.

In general, the Victoria Park contract is notable in the paucity of references to published consensus standards. The city's engineers preferred to go the route of listing in full their own in-house specifications.[73] Some of these are given in detail as in the table for pipe diameters and pipe wall thicknesses. Others remain at the level of qualitative vagueness that *The Canadian Engineer* complained about almost a quarter century earlier, using terms such as "tightly riveted" and "amply stiffened." Yet others are simply puzzling, such as the specification that the metered flow of water be within 1% "of the true flow"—determined how? Not surprisingly, the city got some of the same back from its contractors. R. S. Nicholas, Chief Draughtsman of the McGregor-Mcintyre Iron Works Ltd, told the project's general contractor, Dominion Construction Corp. Ltd., that in painting gratings "we propose using the same specification of paint with the addition of a small amount of black in order to get better covering quality." The contract made some use of published standards. Cast iron had to conform to the ASTM standard and the contract gave a protocol for field tests. When the Toronto Iron Works Ltd. ordered rivets for the project from the Steel Company of Canada they too had to conform to ASTM standards as well as being "inspected by City of Toronto Inspector." Electrical work, by law, had to satisfy Ontario Hydro's regulations. Samples of locks left by a representative of Vokes Hardware Company drew the critical observation that while they were to US standards this differed by an eighth of an inch from the city's. After consultation with the City Building Department, Works Department engineers rejected a contractor's proposed substitution of a branded product, "Cincrete" for concrete tile. It did not meet specifications for freedom "from sulphur or other corrosives." Like Titans discussing bread crumbs, Richard Hearn, then with Dominion Construction, wrote to R. C Harris in some satisfaction to inform him "[w]e have been able to get the manufacturer of the steel cones to revise his method of testing the two closing pieces [for discharge headers] so as to reduce their price to us, which reductions we are passing on to the City."[74]

The spotty references to external standard specification form a stark contrast to the Ashbridge's Bay contract. In addition of course to the city's own Building By-Law, the contract makes reference to a host of standards as shown in Table 1 (page 24). The province's metropolis was thus not merely the base of operations for extending the reach and impact of industrial standards but also led by example in their usage.

CONCLUSION

This study enables us to draw a few conclusions about the roles played by public works in Ontario between the wars, conclusions that it would be useful to test against case studies from other jurisdictions. These conclusions relate to industrial practice, the position of engineers and the provincial state.

In their early, extensive and rigorous use of technical standards public works helped to raise the standard of industrial production in Ontario. This paper has shown specific instances of influences and also how contemporaries viewed the matter. Why were public works so advanced in this regard? In part the answer is scale and scope. Like other large private entities, public works bodies could command the services of very good engineers, had particular incentives to stand-

Table 1
Ashbridge's Bay Sewage Treatment Contract Standards

Item	Standard
Reinforcing steel	ASTM and CESA as alternatives
Cement	CESA
Aggregate	Shortened by reference to CESA Concrete tests CESA
Asphalt	ASTM including a tentative specification
Steel	ASTM
Copper	ASTM
Creasoting	Manual of the American Railway Engineering Association
Structural steel and wrought iron	Material to ASTM, workmanship to CESA
Sluice gates	American Water Works Association but cast iron to ASTM
Valves	American Water Works Association
Steel pipe	ASTM
Electrical equipment	Canadian Electrical Standards Association [sic] and Ontario Hydro
Meter tubes	American Water Works Association
Rails	ASCE
Motors	AIEE
Electric power and lighting	AIEE and Ontario Hydro
Vitrified pipe	ASTM
Lightning rods	Lightning Rod Act of Ontario

Legend : AIEE: American Institute of Electrical Engineers ; ASTM : American Society for Testing Materials; CESA: Canadian Engineering Standards Association.

Source : A copy is in the Dallyn Papers, AO MU 813, box 49, in full *City of Toronto Department of Works Ashbridge's Bay Sewage Treatment Plant Contract for the Construction of Sedimentation Tanks, Digestion Tanks and Sea Wall.*

ardize their own operations, had the economic clout to impose their will on suppliers and could distribute the costs of writing and supervising exacting specifications across a wide range and volume of economic transactions. Public works as well had at least two other factors working to encourage use of consensus standards. First, as public entities they had a particular commitment to the open flow, rather than proprietary control, of technical information.[75] Not surprisingly, public sector engineers from government and public universities and what we might call quasi-public sector engineers from journalism, trade association and private universities, have been over-represented on institutions such as engineering standards committees dedicated to the pooling and distributing of technical knowledge. Second, while private firms could favour particular other firms or not as they wished, such behaviour was far more problematic for public bodies. The use of consensus standards represented a way of obviating political problems that could otherwise arise from contract specifications which too obviously favoured one firm over another.[76]

In their promotion of the use of consensus standards public works advanced the professional interests of engineers. Consensus standards are a way for engineers to talk to other engineers. Like any other argot it is an exclusive discourse. Those like the editor of *The Canadian Engineer* who called for improvements in contract specification did not hesitate to make clear that this also meant the employment of more well-qualified professional engineers to supervise works. The innovative methods for testing and controlling concrete quality developed by R. B. Young explicitly required final control to rest with him and his colleagues in a Toronto laboratory, not with supervisors at a cement plant or foremen along the Niagara River. Increasingly technical specifications for the urban public works meant that city engineers could hope for greater independence from political oversight of their work from non-technically trained aldermen.

Finally, the use of technical specifications, especially where backed up by statutory or regulatory fiat, reinforced the power of the provincial state. Standards, as Shapiro has observed, "provide a means of mapping the universal onto the local."[77] Fortunately for the W. A. McLeans and Frederic Dallyns of the province, they operated in an environment of broad consensus on the perceived rationality of science and virtuousness of technical progress. Still, the particular ideas and ambitions of public servants in Toronto informed the construction of the built environment, the health and the mobility of citizens throughout the province. To the extent that those ideas further gained adoption beyond their immediate embodiment in public works, through changed industrial practice, they further informed the manner in which many Ontarians spent their working days.

NOTES

1 The definition is that of the American Society for Testing and Materials (ASTM) in their pamphlet *What is ASTM?* (West Conshohocken, Pa., ASTM, 1999), n. p.

2 Ken Alder, *Engineering the Revolution: Arms and Enlightenment in France, 1763–1815* (Princeton: Princeton University Press, 1997); H. Otto Sibum, "Les gestes de la mesure: Joule, les pratiques de la brasserie et la science," *Annales: Histoire, Sciences Sociales* 53 (1998): 745–74; D. J. Puffert, "The Standardization of Track Gauge on North American Railways, 1830–1890," *Journal of Economic History* 60 (2000): 933–60; William J. Ashworth, " 'Between the Trades and the Public': British Alcohol Standards and the Proof of Good Governance," *Technology and Culture* 42 (2001): 27–50.

3 Alfred D. Chandler, jr., *The Visible Hand: The Managerial Revolution in American Business* (Cambridge: Belknap Press, 1977); Janet Knoedler and Anne Mayhew, "The Engineers and Standardization," *Business and Economic History* 21 (1994): 141–51.

4 Amy Slaton, " 'As Near as Practicable': Precision, Ambiguity, and the Social Features of Industrial Quality Control," *Technology and Culture* 42 (2001): 51–80; idem, *Reinforced Concrete and the Modernization of American Building, 1900–1930* (Baltimore: Johns Hopkins University Press, 2001); Amy Slaton and Janet Abbate, "The Hidden Lives of Standards: Technical Prescription and the Transformation of Work in America" in *Technologies of Power: Essays in Honor of Thomas Parke Hughes and Agatha Chipley Hughes,* ed. Michael Thad Allen and Gabrielle Hecht (Cambridge: MIT Press, 2001), 95–143.

5 Alder, *Engineering the Revolution.*

6 See Tom Traves, *The State and Enterprise: Canadian Manufacturers and the Federal Government, 1917–1931* (Toronto: University of Toronto Press, 1979); and Christopher Armstrong and H.V. Nelles, *Monopoly's Moment: The Organisation and Regulation of Canadian Utilities, 1830–1930* (Philadelphia: Temple University Press, 1986).

7 For instance, Bruce Sinclair, *Centennial History of the American Society of Mechanical Engineers, 1880–1980* (Toronto: University of Toronto Press, 1980).

8 Donald MacKenzie, *Inventing Accuracy: A Historical Sociology of Nuclear Missile Guidance* (Cambridge: MIT Press, 1990); Yehouda A. Shenhav, *Manufacturing Rationality: The Engineering Foundations of the Managerial Revolution* (Oxford: Oxford University Press, 1999).

9 Stuart Shapiro, "Degrees of Freedom: The Interaction of Standards of Practice and Engineering Judgment," *Science, Technology & Human Values* 22 (1997): 286–316.

10 A useful review of the literature on the social construction of scientific knowledge is given in Jan Golinski, *Making Natural Knowledge: Constructi-*

vism and the History of Science (New York: Cambridge University Press, 1998). See also Jed Z. Buchwald, ed., *Scientific Credibility and Technical Standards in 19^{th} and Early 20^{th} Century Germany and Britain* (Dordrecht: Kluwer, 1996); and Simon Schaffer, "Accurate Measurement as English Science" in *The Values of Precision,* ed. M. Norton Wise (Princeton: Princeton University Press, 1995), 135–72.

11 Alexandre Mallard, "Compare, Standardize and Settle Agreement," *Social Studies of Science* 28 (1998): 571–601, cit. p. 594.

12 Graeme Gooday, "The Morals of Energy Metering: Constructing and Deconstructing the Precision of the Victorian Electrical Engineer's Ammeter and Voltmeter," in *The Values of Precision,* ed. Wise, 249–82.

13 Sibum, "Les gestes de la mesure."

14 Bruce Curtis, "From the Moral Thermometer to Money: Metrological Reform in Pre-Confederation Canada," *Social Studies of Science* 28 (1998): 547–70, cit. p. 567.

15 Jeremy L. Stein, "Dislocation: Changing Experiences of Time and Space in an Industrializing Nineteenth-Century Ontario Town," *British Journal of Canadian Studies* 14 (1999): 115–30.

16 Mario Creet, "Sandford Fleming and Universal Time," *Scientia Canadensis* 14 (1990): 66–89.

17 American Water Works Association, *Proceedings* 33 (1913), v.

18 *Standard Methods for the Examination of Dairy Products* (New York: American Public Health Association, 1910) 1–6. American Railway Bridge and Bridge Building Association, *Proceedings of the Twentieth Annual Convention* 6 (1910). American Society of Agricultural Engineers *Transactions* 6 (1912): viii.

19 Compiled from ASTM, *Proceedings* 5 (1905).

20 Good examples, from Ontario, can be found in the records of the Barber Turbine & Foundries Ltd. Archives of Ontario (AO) MS 233, and the papers of James Lewis Morris AO MU4830, whose varied career as a civil engineer included laying out the Sudbury townsite.

21 "The Manufacturers' Specifications," *The Canadian Engineer* (18 May 1911): 711.

22 "Specifications for Re-Rolled Rails," *The Canadian Engineer* (29 June 1911): 891.

23 City of Toronto, Council Minutes, Board of Control Report n^{o} 8 (1913), 423.

24 Tracing the movement of classroom teachings into industrial project remains a task of future historical research, but see University of Toronto Archives, A1966-0011/005(001), Department of Civil Engineering Papers, C.R. Young Correspondence (Hereafter Young Papers).

25 John Galbraith, *Technical Education* (Toronto: Warwick, 1892), 6–8. Water J. Francis, "Engineering at the University of Toronto," *Engineer* 106 (1909), 103–4. For an overview of engineering training at Toronto see Richard White, *The Skule Story: The University of Toronto Faculty of Applied Science and Engineering, 1873–2000* (Toronto: Faculty of Applied Science and Engineering, 2000).

26 For the CSCE generally see J. Rodney Millard, *The Master Spirit of the Age: Canadian Engineers and the Politics of Professionnalism* (Toronto: University

of Toronto Press, 1988), and for its initial interest in standards the *Report of Standards Committee* (Montreal: CSCE, 1906). For trade associations see "Standard Building Regulations for Reinforced Concrete," *Canadian Cement and Concrete Association Proceedings* (1911): 86–89, and "Joint Report of the Meter Committee and the Meter Inspection Committee," *Proceedings of the Canadian Electrical Association* (1911): 101–43.

27 The CSA's own history is presented in a 1994 pamphlet *Making Our Mark on the World.* A contemporary account is given in *The Canadian Engineer* (1 August 1918).

28 Paul Craven and Tom Traves, "Canadian Railways as Manufacturers, 1850–1880," *Historical Papers*, Canadian Historical Association (1983): 254–81. David A. Hounshell, *From the American System to Mass Production, 1800–1932: The Development of Manufacturing Technology in the United States* (Baltimore: Johns Hopkins University Press, 1984). In the case of the military these trends can be dated to before the nineteenth century. See Ken Alder, "Making Things the Same," *Social Studies of Science* 28 (1998): 499–545.

29 John G. Burke, "Bursting Boilers and the Federal Power," *Technology and Culture* 7 (1966): 1–23. Bruce Sinclair, *Philadelphia's Philosopher Mechanics: A History of the Franklin Institute, 1824–1865* (Baltimore: Johns Hopkins University Press, 1974).

30 AO RG15-81, [C.E. Durst] to Hon. Dr. Reaume (1 August 1905).

31 AO RG15-81, Boiler Inspection Reports.

32 Obviously, the Provincial Engineer neither wanted nor needed to ride roughshod over local concerns and sensibilities. See David Siegal, *Provincial-Local Municipal Relations in Ontario: A Case Study of Roads* (University of Toronto, doctoral dissertation, 1982). For the US experience, see Bruce Seely, *Building the American Highway System: Engineers as Policy Makers* (Philadelphia: Temple University Press, 1987).

33 Young Papers, Young to W.A. McLean (4 Nov. 1911).

34 Revised Statutes of Ontario (RSO), 2 Geo. V (1912), c. 11.

35 AO RG15-55-1, Supply Branch Contracts, vol. 12.

36 The following is from AO RG15-12-0-18, container 4.

37 AO RG14-153-1, MS 3905, "Specifications for Construction of Pavements and Curbing with Necessary Drainage on Niagara Boulevard Fort Erie, Ont."

38 AO RG14-153-1, MS 3855, F.A. Sherman to A. Sedgewick (26 November 1933).

39 AO RG15-55-1 Vol.25. The correspondence is Deputy Minister of Public Works to Isaac Ilsley, 11 August 1938.

40 The phrase is Slaton's and Abbate's in "The Hidden Lives of Standards," 99.

41 The Act is RSO, 58 Vic. (1895): 49. As is the case with roads, the relationship between centralism and localism is a complex one, see Mary Powell, *Provincial-Local Relations in Ontario: The Case of Public Health, 1882–1984* (Toronto: University of Toronto, doctoral dissertation, 1991).

42 Jamie Benidickson, "Ontario Water Quality, Public Health and the Law, 1880–1930" in *Essays in the History of Canadian Law,* vol. 8, ed. G. Blaine Bohr and Jim Phillips (Toronto: Osgoode Society, 1999), 115–41.

43 Some biographical information about Dallyn is found in the University of Toronto Archives, Department of Graduate Records, A-73-026/77/53, which consists principally of a file of newspaper clippings. The following discussion is based on his papers at the Archives of Ontario that include annotated contracts and correspondence.
44 AO MU 767, box 5, Westway Co. to Dallyn (10 Nov. 1931).
45 The sand is also known as "Illinois sand." AO MU 763, box 1.
46 AO MU 769, box 7, F.B. Goedike to Dallyan [sic] (10 June 1927), and Dallyn to Goedike (17 June 1927).
47 AO MU 768, box 6, J.P. Howe to Dallyn (12 November 1931), and Dallyn to Howe (14 November 1931).
48 AO MU 765, box 3, laboratory report nº 69 (November 1931), and W.R. Dobson to Dallyn (11 January 1932). In both cases this was done by Hydro for a fee.
49 AO MU 768, box 6, W.A.T. Gilmor to Dallyn (1 May 1931).
50 AO MU 765, box 3.
51 *Ibid.*
52 AO MU 772, box 10, W.S. Leslie to Dallyn (3 September 1929).
53 These examples are all from AO MU 772, box 10.
54 Keith Fleming, *Power at Cost: Ontario Hydro and Rural Electrification 1911–1958* (Montreal and Kingston: McGill-Queen's University Press, 1992).
55 The role of Hydro is discussed at greater length in James Hull, " 'A Giant Engineering Organization': Ontario Hydro and Technical Standards for Canadian Industry, 1917–1958," *Ontario History* 43,2 (2001), 179–200.
56 AO, Richard Lankaster Hearn Papers (hereafter Hearn Papers), MU 8661, box 26. The turbine specifications date from October 1918.
57 Hearn Papers, "National Electric Light Association," AO MU 8667, box 32.
58 Hydro One Networks Inc., Archives, GSI Collection (hereafter Hydro Archives), ORR 842.2, "Report on Cement and Concrete Tests and Specifications" (27 January 1919). See also Amy Slaton, *Reinforced Concrete,* and Benjamin Sims, "Concrete Practices: Testing in an Earthquake-Engineering Laboratory," *Social Studies of Science* 29 (1999): 483–518.
59 The following discussion, except where noted, is from Hydro Archives Accession 91–209, bin 3-11, box 93.
60 Shapiro, "Degrees of Freedom."
61 AO MU 6077, Barber records, "Blueprint for HEPC South Falls Extension" (27 June 1931). Hydro Archives, ORR 831.3.1., "Material Specifications for Turbines" (18 Feb 1939).
62 Standards are only one aspect of a much broader phenomenon relating to the movement of technical information during the second industrial revolution. See James P. Hull, " 'A Common Effort to Determine the Facts': The Sharing of Technical Knowledge in Canadian Industry," *Journal of Canadian Studies* 25 (1990): 50–63.
63 See AO F4142-1-1, Ferranti-Packard Papers Transformer Specifications. These files contain not just specifications and blueprints but also considerable internal and external correspondence relating to them.
64 Slaton and Abbate, "The Hidden Lives of Standards."
65 Hydro Archives, ORR 831.3.1., Purchasing Agent [B.O. Salter] to J.R. Montague (27 October 1937). Shenhav comments "The standardization pro-

gram at Westinghouse [...] was adopted throughout the electrical industry." Shenhav, *Manufacturing Rationality*, 62.
66 The controversy may be followed in the City of Toronto Council *Minutes* for 1912–1915.
67 City of Toronto Council *Minutes* (1913), Appendix A, 218, 258.
68 City of Toronto Archives (hereafter TA) RG 8, box 36, file 1, memo R.59512 (4 October 1926).
69 TA RG 8, box 38, file 2, *Technical Matters Watermains and Sewers*.
70 Dallyn Papers AO MU 767, box 5, *List of Material to be Supplied W.J. Trick & Co. Oshawa, for the City of Oshawa New Filtration Plant.*
71 TA RG 8, box 38, file 1, *Technical Specifications for Pavement,* and RG 8, series 2.3, box 35, file 1, *Department of Works Head Office Manual.*
72 City of Toronto Council *Minutes* (1926), appendix A, 1321–23.
73 The following is from TA RG 8, box 1, files 2-3, *Water Works Extension, Pumping Station and Service Buildings, Victoria Park* (1935, 1936).
74 *Ibid.*, Hearn to Harris, 31 January 1936.
75 Such a commitment was not contrary to nor in conflict with industry interests or practices, see Hull " 'A Common Effort to Determine the Facts'."
76 Consensus standards can of course do that too, but following them at the very least could indicate an ostensible commercial neutrality.
77 Shapiro, "Degrees of Freedom."

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