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A Generic Framework of Performance Specifications for Specialist Works

Patrick T.I. Lam
Associate Professor, The Hong Kong Polytechnic University, Hung Hom, Kowloon, Hong Kong

Mohan M. Kumawaswamy
Professor, The University of Hong Kong, Pokfulam Road, Hong Kong

Thomas S.T. Ng
Associate Professor, The University of Hong Kong, Pokfulam Road, Hong Kong

Abstract
With the advent of the Design and Construct procurement approach, there has been a trend of specifying construction works by performance. The perceived benefits of Performance Specifications are mainly innovation and the possibility of contribution by specialist designers. Yet, the lack of a suitable framework for specifying specialist works sometime causes bitter disputes and costly rectification works.

As part of a recently completed doctoral research by the first author, a useful generic framework of Performance-based Specifications has been proposed and established using data from 5 case studies of curtain wall installations in Australia, Hong Kong and Singapore. Curtain wall was chosen due to the specialist design and stringent testing requirements, which are often based on performance specifications. The proposed generic framework consists of two levels. The first level consists of five generic headings (i.e., General Requirements, Performance Requirements, Product Requirements, Execution Requirements and Evaluation Requirements), which can be used to group all specified details irrespective of the nature of the installation. The second level consists of work-specific details but they need only minor adaptations to suit different works. This generic specification framework has been validated as being applicable to other types of performance-based work in accordance with published criteria and tested with two different real projects in Hong Kong and Singapore.

In addition, works which are suitable for Performance Specifications are discussed and they include those for which performance criteria are measurable and achievable. The pitfalls of specifying by performance have also been identified and recommendations have been given for problem avoidance and general improvements.

Keywords
Performance Specifications, Specialist Works, Generic Framework, Performance Criteria

1. Introduction

There has been a trend of specifying construction works by performance, especially due to the increased use of the Design and Construct procurement approach and the specialization of construction trades. The benefits expected from Performance Specifications are usually to leave room for innovation and other contributions by specialist designers. Although some rudimentary guidelines exist as to the presentation of performance criteria at the component level, such as those published by the Ministry of Public Building Works (1969) and BS6019-1980 in the UK, the lack of a suitable framework for, and approaches to specifying specialist works sometime leads to conflicting interpretations, bitter disputes and costly

rectification works. This paper conveys relevant findings from part of the first author's completed doctoral research, where a generic framework for specifying specialist works by performance was developed and validated by a case study approach.

2. Framework Development from Case Studies

Five case studies were carried out on specification samples from Hong Kong (2 projects), Singapore (2 projects) and Australia (1 project). This combination of case study projects in different countries/cities ensures that there is no bias or predisposition in studying the approach to specifications preparation.

To enable drawing up a common framework and making cross comparisons, all the sample specifications chosen are of glass curtain walls for commercial/offices developments. Curtain walls have long been the realm of specialist design and the industry is used to their specifications by performance. The details of the case study projects are tabulated in Appendix 1, together with the extracted contents of the specifications. The consultants who produced the Performance Specifications are recognised experts in façade and curtain wall designs.

The format of the specification samples varies and the headings used by the specification writers are not necessarily the same as those in the proposed framework. Some of the information are scattered throughout the body of the specifications. Therefore, it was necessary to extract information from the sample specifications for grouping into relevant sections of the proposed common framework. The proposed framework is comprised of five sections, namely, Section A (General Requirements), Section B (Performance Requirements), Section C (Product Requirements), Section D (Execution Requirements) and Section E (Evaluation Requirements). The following observations on the sample specifications are based on the order of items as appearing in Table 1, using the same reference numbering system.

A.1 Design explicitly included in the Scope of Works of Specialist Contractor
All the specifications examined in this study include design or "engineering" in their Scope of Works statements. The SEC project, in particular, specifies that a complete air and watertight enclosure is required. Of the five samples, only the BSRTO project mentions that it is a performance specification.

A.2 Detailed Scope Statements
Each sample contains detailed scope statements, which describe the curtain wall systems, the related works (such as louvers and skylights) and testing either by parts of the building (e.g., podium and towers) or by elevations.

A.3 Intended use of the building
Not all samples contain statements of the intended use of the buildings (with the BSRTO project being the only notable exception with clear indications). From case law (e.g., *Stormont Main Working Men's Club and Institute Ltd. vs J. Roscoe Milne Partnership, 1988, where an architect escaped liability for designing snooker facilities which did not have sufficient space for competition play on the grounds that the employer did not state this intended use clearly*), if the employer requires "fitness-for-purpose" responsibility to be borne by the specialist who carries out design work, it would be advisable to specify the intended use of the building clearly.

A.4 Design life requirement
Only 2 sample specifications (PRI and BSRTO) contain requirements on the design life for the curtain walls. A complete Performance Specification should state the expected life span of the facilities, but if that is missing, courts will imply a reasonable life span for a product when a dispute arises (Lupton, 1996). Although it may be difficult to verify the achievement of design life in practice, this requirement, if specified, would give designers a clear indication of durability expectations. With the development of accelerated climate testing techniques on materials, it would be possible to predict the design life of major

components with reasonable accuracy by requiring manufacturers' certification of the tested lives of their products (e.g., sealants).

A.5 Submission requirements

All sample specifications contain submission requirements of shop drawings, samples and calculations, with different details being specified for different stages (tender stage and after contract is awarded) or for different purposes (e.g., for information, approval and review). Only BSRTO specifies a time frame for review and approval to give assurance for contractor's programming.

A.6 Mock-up requirements

All sample specifications contain a specification of mock-up installation on or off site (i.e., in approved laboratories) for prototype testing and visual inspection before full scale installation on site. The sketches attached to the specifications show the combinations of glass configurations envisaged by the curtain wall consultants (including operable sashes and fixed lights at different locations, e.g., main elevations and corners). Two sample specifications (PRI and LC) indicate the required timing of the mock-up installations to ensure the timely feedback of test results into the design and production process.

A.7 Alternative tenders invited

Three out of the five specification samples contain optional items as an invitation of alternative price submissions from tenderers. The inclusion of such options reflects that the employers wish to compare the prices of alternative designs. Upon award of contract, the employer's representatives have to state the option adopted before further detail design work can proceed.

A.8 Warranty Period

All the five specification samples require the specialist contractors to commit to warranty of the curtain wall systems. Within three samples, the lengths of warranty periods differ amongst the component parts of the same system. The specified commencement dates also differ amongst different specifications (some use Practical Completion, whilst some use the expiry of the Defects Liability Periods as the starting points).

A.9 Use of Standards

Curtain wall installations have typically been based on a multiplicity of technical standards, including American standards, British standards, etc. Four out of the five specification samples made it clear that standards used in the home country of the manufacturers may be substituted for the specified standards provided that acceptance is given by the Architect and the Building Authority. They also state that priority of interpretation should be given to the more stringent requirements if conflicts exist.

A.10 Interfacing requirements

All the sample specifications state the works related to (but not forming part of) the curtain wall installations. Typically, these include lightning protection works, window cleaning works, stoneworks, etc., for which the specialist contractors have to co-ordinate with each other. All the samples inspected contain the requirement for the supply of cast-in anchors for incorporation into the structures of the buildings to be cladded.

B.1 to B.12 Performance requirements

All sample specifications contain numerical performance criteria for permissible deflections (frames and glass), thermal movement, air infiltration, water penetration, vision glass performance, tolerances (for structure erected by the main contractor, building movement and the curtain wall installations themselves). More qualitative criteria are specified for fire/smoke separation, cast-in anchors, corrosion resistance, maintenance features and maintenance manuals. Some prescriptive elements have been included for the fixing of fire safing insulation (by specifying branded materials and supports) between curtain walls and structural slabs (ref: BOC, PRI and LC projects). An example of specifying fire separation by

performance is the BSRTO project, which only refers to the Building Code of Australia. A notable feature on life cycle performance is the specification that glass should be replaceable after construction in three of the five samples examined.

C.1 to C.6 Product requirements

All the sample specifications list the appropriate technical standards for the major materials, including aluminium extrusions and sheets, carbon steel, stainless steel, aluminium coatings and sealants. Some variations exist in the reference information given for the standards, e.g., when carbon steel is specified to comply with ASTM A36 in nearly all samples, one set of specification (PRI) indicates the year of publication as 1994 whereas other specifications (BOC and LC) contain no such indication. Similar variations exist for fluorocarbon coating, which is specified to comply with AAMA 605.2-1990 for LC project, but only to AAMA 605.2 for SEC project. In all cases, adequate details should be given to avoid doubt.

As for sealants, two of the sample projects specify for these by stating the relevant standards whereas three sample specifications give specific brand names and model numbers. The latter practice is not uncommon for "hybrid" or Performance-based Specifications containing performance standards and proprietary product information.

D.1 to D.6 Execution requirements

Although Performance-based Specifications do not spell out how the works should be carried out, there is a need to indicate the workmanship requirements.

All the sample specifications indicate preference for factory assembly rather than site assembly for better quality control. Three out of five samples require manufacturers' certification that products (or finishes) have been utilised (or applied) in accordance with their instructions. Two project specifications (SEC and BSRTO) require glass and sealants manufacturers to confirm suitability for purpose or compatibility. These practices have the effect of implicating manufacturers, who are not parties to the curtain wall contracts, in the quality assurance process.

The engagement of Professional Engineers by the specialist contractors are made mandatory in all the sample specifications examined. Their roles are to witness and verify all tests and designs of the curtain wall installation, as well as to deal with statutory approval and submission matters. This is a feature of Design & Build contracts, when the contractors are responsible for statutory submissions.

Other common execution requirements include welding and glazing with structural silicon sealants. Protection and cleaning clauses are put at the end of all the sample specifications.

3. Synopsis of the Proposed Framework

A generic version of the proposed framework of Performance Specifications as developed from the 5 case study projects on curtain walling is shown in Table 1 in the form of a matrix. The five sample specifications on curtain walls fit well into the proposed framework in terms of contents and logical grouping (approximately 95 per cent by observation), although not all sample specifications contain the necessary information to fulfill every component of the framework to produce an otherwise complete Performance Specification (e.g., design life is not specified in three of the five projects). The proposed framework consists of two levels. The first level consists of five generic headings (i.e., General Requirements, Performance Requirements, Product Requirements, Execution Requirements and Evaluation Requirements), which can be used to group all specified details irrespective of the nature of the installation. The second level consists of work-specific details but they need only minor adaptations to suit different works. For example, B3 (max. deflection of other members) for curtain walls can be converted to "panel deviation" in the case of specifications for raised access floors.

Table 1 The Proposed Generic Framework for Performance Specifications

Level 1 Groupings					
Item	**A. General Requirements**	**B. Performance Requirements**	**C. Product Requirements**	**D. Execution Requirements**	**E. Evaluation Requirements**
Level 2 Details					
1	Design explicitly included in Work Scope	Design loads and factor of safety	Specified standards for major components	Fabrication locations	Product tests
2	Detail scope statement (indicating applicable parts of building)	Max. deflection of framing members	Specified standards for entire system	Manufacturers' certification	Mock-up tests on full-scale set-up (indicating time required)
3	Specific purpose/use of building stated	Max. deformation of other members	Specified standards for supports	Professional engaged by specialist	Field tests on portions of system
4	Design life requirement	Allowable thermal movement under specified temp. range	Specified standards for ancilliary materials	Fixing requirements (e.g. welding)	<u>Notes on evaluation methodologies</u>:- *As far as possible, testing should be carried out to recognised standards.* *Inspection should be carried out on works that would be concealed upon completion.* *Observation and demonstration should be used to verify performance if no objective testing method is available.*
5	Submission requirements	Air infiltration limits / Sound Insulation requirements	Specified standards for finishing	Installation standard	
6	Mock-up requirements	Water infiltration limits	Specified standard for sealants, etc.	Protection and cleaning	
7	Alternative tenders invited	Component performance	<u>Notes</u>:- *Where necessary, proprietary products can be specified provided that:* *(i) their properties do not contradict with other stated performance requirements;* *(ii)there is no prohibition from procurement rules of client*	<u>Notes</u>:- *Other execution requirements can be added as necessary but care should be taken not to dictate the method of execution.*	
8	Warranty Period	Tolerances of components and system			
9	Use of Standards	Fire / smoke separation			
10	Interfacing requirements	Cast-in Components			
11	Maintenance manual	Resistance to corrosion, etc.			
12		Maintenance features			

4. Validation of the Proposed Framework

The Lupton Stellakis report (1994) proposed that a complete Performance Specification should include four ingredients: (i) an identification of the particular level of the spatial hierarchy to which the Performance Specification is applied; (ii) the amount of "performance" content in the specification (i.e., whether performance requirements outweigh prescriptive requirements in terms of proportional contents); (iii) the incorporation of the context of time (i.e. life spans of components or system); and (iv) the evaluation methodologies.

The proposed framework enables specifiers to meet all these requirements in the following ways, using the same reference order as mentioned in the report and the proposed framework in Table 1:-

(i) Item A2 (Definition of scope) states the parts of the buildings to which the Performance Specification applies.

(ii) By adopting the proposed framework as a template and filling in the necessary details, specifiers will achieve a "performance-based" specification, given the fact that the majority of items in the framework are performance requirements, whilst some product requirements can be stated either in performance terms or based on proprietary products.

(iii) Item A4 (Design life) is for the specification of design lives of components and systems whereas Item E2 (Mock-up tests) prompts the specifiers to indicate the required timing of mock-up testing to enable timely feedback.

(iv) Item E1 to Item E3 remind the specifiers of the three levels of evaluation and the associated notes give guidance on the methods of evaluation.

Thus, it is hypothesised that the proposed framework can be applied reasonably well to other types of performance-based work. In order to validate this hypothesis, the contents of the Performance-based Specifications of the raised access floor systems and suspended ceiling systems of two infrastructure projects (West Rail in Hong Kong and Mass Rapid Transit in Singapore) were fed into the proposed framework. These two projects were chosen for their relatively similar nature and independence from each other since they are located in two different cities with no overlaps in project teams. Results demonstrate that all the essential requirements from these Performance Specifications can be systematically laid out within the proposed framework. Only slight modifications to the framework developed from the curtain wall case studies were necessary to reflect the different nature of work due to technical differences inherent with raised access floors and suspended ceilings. For example, the heading "glass performance" was changed to "panel performance" to suit the context of the raised floor and suspended ceiling installations. In this way, it can be established that the generic framework as shown in Table 1 can be used for specifying different types of works by performance. It can aid specifiers to ensure that their specifications contain the necessary information for the specialist contractors to design and install the facilities without hitch. The potential benefits are evident with the case study projects (curtain walls, raised access floors and suspended ceiling), the specifications for which contain the necessary information but in dispersed locations which are difficult to find. A logical grouping of information greatly assists the users of specifications. In particular, this proposed framework can assist estimators in pricing for performance-specified works, which are not presented in a "priceable" format. All they need to do is to extract the relevant information from the specifications and feed into the framework for a systematic analysis of prices. They can then make cross comparison of the performance requirements between different projects more efficiently and price more accurately from their in-house project cost database than would be the case if the Performance Specifications are interpreted in isolation from one another.

5. Works Suitable for Performance-based Specifications

Performance specifying has a far greater impact on project team dynamics than other specification methods (Wyatt, 2001). On the part of designers, the use of Performance Specifications challenges their technical, administrative and analytical skills when the documents are prepared, proposals are evaluated, and recommendations are made. On the part of contractors, the strict common law obligation of "fitness for purpose" (i.e., the completed works must be reasonably fit for the intended purpose previously made known to the contractor by the employer) is implied in Performance Specifications unless expressly reduced to that of reasonable skill and care. Lack of experience in the performance specification method

can financially hurt project team members unfamiliar with these demands. To be effective, the method of specifying by performance is appropriate only when empirical values can be readily expressed in the documents and standard tests can be performed to verify compliance with quality requirements. Hence, Performance Specifications are suitable for large engineering projects or components which are pre-engineered, tested and certified for compliance. Other suitable project types include those in which the owner's main objective is an inexpensive or innovative solution with minimum control over product selection or aesthetic criteria (Wyatt, 2001).

6. Pitfalls of Performance Specifications

Hartman (1997) quoted a US attorney whom he interviewed as saying that "an unsophisticated owner reading a Performance Specification thinks of a Mercedes-Benz, while the contractor sees a Volkswagen". This quotation describes aptly the dilemma of specifying by performance. The owner regards a Performance Specification as the baseline of his quality requirements whereas the contractor takes the Performance Specification as setting the functional limits for his works. This would happen if the owner and the specifier do not communicate their expectations clearly, especially on aesthetic aspects.

The use of Performance Specifications by designers have been criticised for passing design responsibility downstream. Whilst this may be the case, designers still retain accountability for the outcomes of the design results since they should reliably advise the client as to whether a proposed solution would in fact meet the performance requirements.

7. Conclusion

A framework of Performance-based Specifications was established based on 5 case studies of curtain wall installations in Hong Kong, Singapore and Sydney. This specification framework was validated as being applicable to other types of performance-based work in accordance with the criteria cited by Lupton and Stellakis (1994) and tested with 4 specifications from 2 projects. Works suitable for Performance Specifications include those for which performance criteria are measurable and achievable. The pitfalls of specifying by performance have been identified for avoidance by specifiers.

Acknowledgement

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Appendix 1

Case Study Projects used for establishing Generic Framework for Performance Specifications

		Hong Kong Projects		Singapore Projects		Sydney Project
	Information	**BOC**	**PR1**	**LC**	**SEC**	**BSRTO**
1	Project Location	Garden Road, Hong Kong	Tsimshatsui, Hong Kong	Orchard Road, Singapore	Shenton Way, Singapore	Berry Street, North Syndey
2	Purpose of Building	Banking hall & offices	Retail and Offices	Retail and Offices	Offices	Retail, offices and Residential
3	Main Structure	Structural Steel + Reinforced concrete	Structural Steel + Reinforced concrete	Reinforced concrete	Reinforced concrete	Reinforced concrete
4	Building Configuration	70 storeys	30 storeys	23 storeys	6-level podium + 29 storeys	6-level podium + 28 storeys
5	Year of Construction	1985-1989	2001-2003	1990-1993	1998-2001	2002-2005