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GUIDELINES ON USE OF INTERNAL MODELS FOR LIABILITY AND CAPITAL REQUIREMENTS FOR LIFE INSURANCE PRODUCTS CONTAINING INVESTMENT GUARANTEES WITH NON-LINEAR PAYOUTS

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1 INTRODUCTION

1.1 FUNDAMENTALS

1.1.1 The Insurance (Valuation and Capital) Regulations 2004 ("the Regulations") prescribe the manner of calculation of liabilities and computation of the regulatory liability and capital requirements for insurance products. However, as more complex insurance products are offered in the marketplace, the Regulations may not fully address the risks arising from these complex products which contain investment guarantees with non-linear payouts. As such, some insurers have developed internal models for liability and capital requirements for such products.

1.1.2 The Guidelines on use of internal models for liability and capital requirements for life insurance products containing investment guarantees with non-linear payouts ("the Guidelines") apply to any direct life insurer registered under the Insurance Act (Cap. 142) ("the Act") who intends to develop and use internal models for variable annuity policies for the purposes of seeking an exemption ("the exemption") from the prescribed manner for calculation of liabilities and computation set out in the following provisions in the Regulations:

(a) regulations 20(2) and 20(5);
(b) paragraph 4(2) of the Third Schedule;
(c) paragraph 3(7) of the Fourth Schedule; and
(d) paragraph 4(3) of the Fourth Schedule.

1.1.3 The Monetary Authority of Singapore ("the Authority") will consider granting the exemption, which may be subject to conditions, if the internal model reflects the regulatory liability and capital requirements for the insurer's products accurately. The Guidelines set out the Authority's expectations of an insurer which seeks the exemption to use its internal models to determine the regulatory liability and capital requirements for life insurance products with investment guarantees which have non-linear payouts.

1.1.4 Once the insurer has been granted the exemption, any conditions to the exemption will apply to the insurer. The exemption conditions may contain paragraphs of the Guidelines, but on a mandatory basis.

1.1.5 The Guidelines provide general guidance, and are not intended to be comprehensive or replace or override any legislative provisions. They should be read in conjunction with the provisions of the relevant legislation, the subsidiary legislation made under the relevant legislation as well as written directions, notices, codes and other guidelines that the Authority may issue from time to time pursuant to the relevant legislation and subsidiary legislation.

1.1.6 The onus is placed on the insurer to demonstrate to the Authority that the model is appropriate for regulatory liability measurement and capital purposes. In this context, an insurer should perform an internal assessment against the Guidelines before applying to the Authority for the exemption.

1.1.7 The Guidelines are structured as follows:

(a) Part 2.1 explains the general application process for the exemption so that the insurer may use internal models.
(b) Part 2.2 lists the conditions that an insurer should observe for the Authority's assessment of internal model.
(c) Part 2.3 lists the information expected for application.
(d) Part 3 sets out the minimum standards that an insurer is expected to observe for the use of internal model.

1.1.8 The expressions used in the Guidelines, except where expressly defined in the Guidelines or where the context otherwise requires, have the same respective meanings as in the Act and the Regulations.

2 APPLICATION AND ASSESSMENT PROCEDURES

2.1 GENERAL PROCESSES

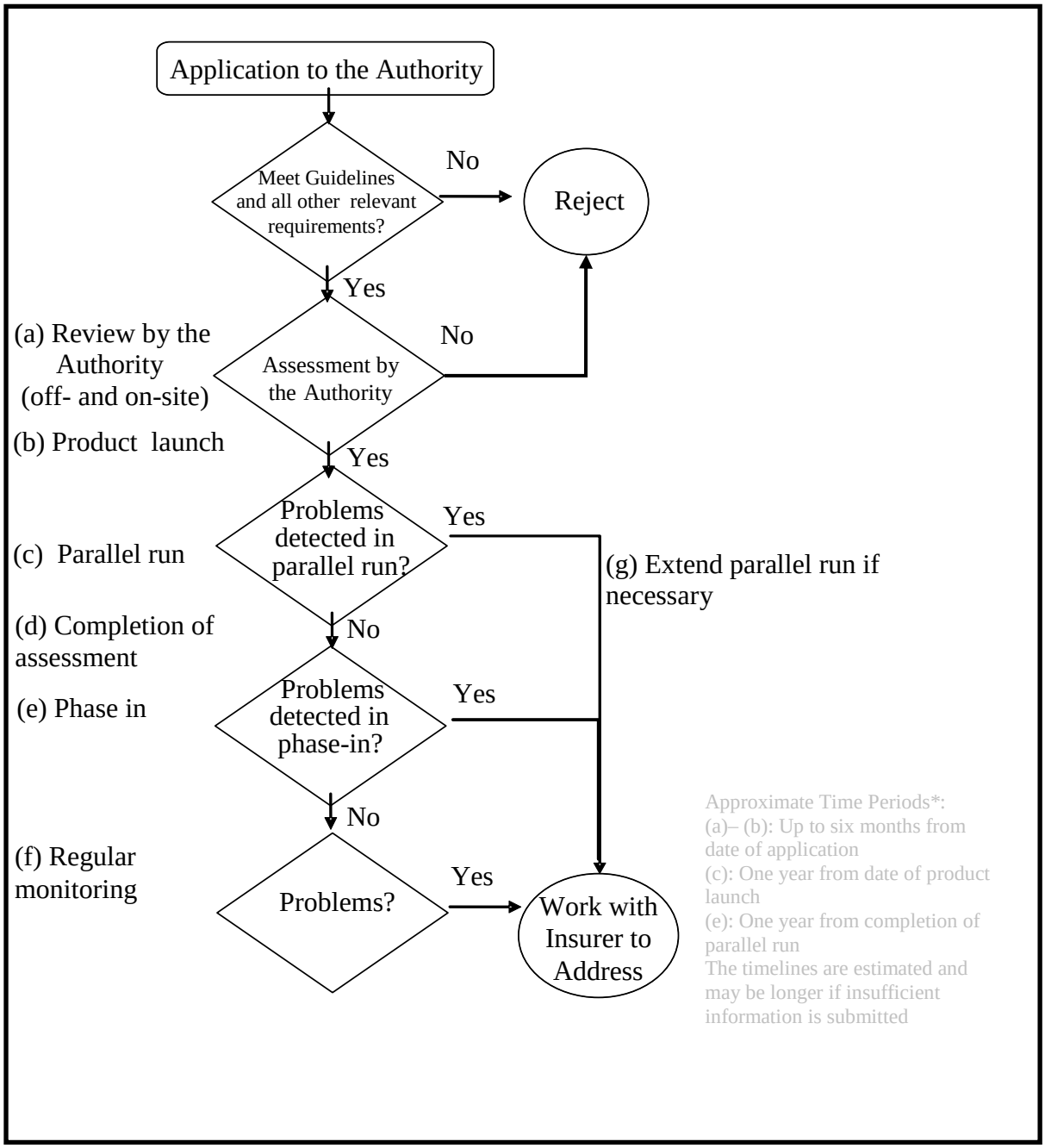
2.1.1 An insurer should not regard the standards in the Guidelines as an exhaustive checklist to be satisfied in order to obtain the exemption. As part of its assessment process, the Authority will consider the ability of the insurer to maintain and improve its systems to ensure the continuing appropriateness of the liability and capital requirements generated by the model. Where appropriate, the Authority would recommend additional standards or vary the Guidelines to take account of the nature, scale and complexity of the insurer's business and risks. For the avoidance of doubt, this Guideline applies in addition to, and does not replace, all relevant legislation and guidelines, such as MAS Notices 302, 307, and 319.

2.1.2 An insurer should integrate the internal model into the overall process of planning, monitoring and controlling the insurer's risks, and be used for operational management purposes so that its results are used as inputs into the risk management strategy and business plan of the insurer. The insurer should inform the Authority if risks associated with any product covered by the internal model are to be transferred to a third party, for example, via a reinsurance or hedge arrangement with a third party. Notwithstanding the transfer of the risks associated with the product, the Guidelines are applicable in their entirety as every insurer is required to honour their obligations to policy owners in the first instance regardless of the risk mitigation measures it has put in place.

2.1.3 The Authority's assessment process may take up to six months from the date of application by an insurer as this is a highly involved process which would involve frequent interactions between the Authority and the insurer and the Authority would need to review the various documentation submitted. An insurer is therefore encouraged to approach the Authority for a discussion of its application well in advance of the date of its targeted product launch.

2.1.4 The process of application and assessment is described in Box 1.

Box 1: Application Procedures



2.1.5 An insurer should apply to the Authority for the exemption with the information, as listed in part 2.3. Upon application by an insurer, the Authority will conduct an assessment of the insurer's use of the model, which will include an off-site review of technical documentation and procedures, on-site inspection of operational processes and discussions with the relevant personnel. During the assessment process, the Authority may also consult the insurer's home regulator, where necessary.

2.1.6 If the Authority is satisfied with the outcome of the assessment, it will grant the exemption and the insurer may use its internal model, subject to such conditions as the Authority may impose in respect of the exemption[1]. For the avoidance of doubt, an insurer would still need to comply with product approval and fund requirements under MAS Notices 302 and 307.

2.2 ASSESSMENT OF INTERNAL MODEL

2.2.1 An insurer should meet the following regulatory requirements for the policy liability valuation and the risk requirements for life insurance products with investment guarantees which have non-linear payouts[2]:

(a) Unit Reserves = Total value of units less surrender charge

(b) Non-Unit Reserves = Max [CTE(70)[3] of present value of cash flows based on best estimate assumptions with margins for adverse deviations, zero] as determined by running a set of scenarios using the internal model;

(c) C1 and C2 Duration Mismatch Risk Requirement = CTE(95) value less the non-unit reserves, where:

CTE(95) value = Max [CTE(95) of present value of cash flows based on the same best estimate assumptions, margins and investment scenarios in sub-paragraph (b), CTE(95) of present value of cash flows based on the same investment scenarios in sub-paragraph (b) and best estimate assumptions without margins for adverse deviations, zero];

(d) C2 investment risk requirement and C3 risk requirement shall continue to be determined in the manner provided in the Regulations.

[1] Please refer to paragraphs 1.1.2 and 1.1.3 above.
[2] The requirements set out are in relation to a "typical" variable annuity product, where there is an investment in an underlying investment-linked policy sub-fund and the guarantee on the product is provided for in the non-unit reserve. The requirements may differ for products with significantly different features.
[3] A conditional tail expectation set at X%, or CTE(X), is the average cost of the highest (100-x)% of the simulated results.

2.2.2 Subject to paragraph 2.1.6, the insurer will be able to launch its product. However, the insurer should conduct a parallel run for one year from the date of product launch ("parallel run") where its policy liability, C1 and C2 duration mismatch risk requirements will be calculated as the highest of:

(a) its internal model value generated using the specifications set out in paragraph 2.2.1;

(b) the floor set by the Authority ("floor"), which is the higher of:

i. The total premiums received net of withdrawals;

ii. The total unit value gross of surrender charges; or

(c) any other value as determined and specified by notice in writing by the Authority to the insurer.

2.2.3 During the period of the parallel run and phase-in period[4], for the purpose of assessing model performance, an insurer should lodge the following documentation with the Authority within 3 months from the last day of each accounting period (except if otherwise stated by the Authority):

(a) Asset value scenarios used by the internal model[5];

(b) Validation report as per paragraph 3.4.2 and Appendix A (paragraphs 17 to 19) – at the commencement of the parallel run as well as the phase-in stage, and annually thereafter as stated above;

(c) Description and results of back-tests as required under paragraph 3.5.6 and stress tests as required under paragraphs 3.5.7 to 3.5.9;

(d) Liability and capital requirements computed, including the results generated by the model and those calculated according to the floor provided by the Authority;

(e) Progress on any outstanding issues identified by the Authority since the Authority allowed the insurer to use its internal model, as per paragraph 2.1.6;

(f) Changes to any of the documentation submitted under paragraph 2.3.1, similar to the requirement under paragraph 2.2.7; and

(g) Any additional reports for the purposes of monitoring the insurer's use of the model.

A member of senior management with oversight responsibility of the internal model should sign off on the accuracy and completeness of the above documents.

[4] The subsequent one year from the completion of assessment by the Authority (referred in Box 1: Application Procedures in Page 4).
[5] Insurers are expected to provide a summary of the scenarios used, highlighting in detail the assumptions and parameters underlying the most adverse scenarios.

2.2.4 At the end of parallel run when the Authority is satisfied with the insurer's internal model, the liability and risk requirements in paragraph 2.2.2 to be applied during the phase-in period, will be the higher of:

(a) the value generated by the internal model using the specifications set out in paragraph 2.2.1;

(b) the value generated based on Table 1 below:

Table 1: Phase-in requirements[6]

Quarter	Liability and Capital Values Generated by Internal Model	Floor Imposed by the Authority
At End of Parallel Run	50%	50%
End of 1st Quarter	62.5%	37.5%
End of 2nd Quarter	75%	25%
End of 3rd Quarter	87.5%	12.5%
End of 4th Quarter	100%	0%

2.2.5 If an insurer becomes aware during the period of the parallel run or the phase-in period that any of the information submitted under part 2.3 is no longer valid, it should:

(a) inform the Authority immediately;

(b) assess the effect of the situation in terms of the risks posed;

(c) prepare a plan to rectify the situation and inform the Authority of its plan as soon as practicable; and

(d) undertake prompt corrective action within a reasonable time in accordance with the plan prepared under sub-paragraph (c).

[6] Assume that the aggregate of liability and capital values generated by the internal model at the end of the first quarter after the completion of the parallel run is $500, while the floor imposed by the Authority is $100. The aggregate of liability and capital requirements on the insurer as indicated by Table 1 is to be computed as 62.5% of the value generated by the insurer's internal model, and 37.5% of the floor as imposed by the Authority during the parallel run. Applying these percentages, the liability and capital requirement on the insurer is 0.625 x $500+ 0.375 x $100 = $350. Since the requirement would be to use the higher of the value given by the insurer's internal model or the computed value using Table 1, the insurer would need to set aside a liability and capital requirement of $500. Conversely, if the value generated by the internal model is $50, while the floor imposed by the Authority is $100, the insurer would have to hold $68.75, being the higher of the value generated by the internal model ($50) and the computed value using Table 1 (0.625*$50+0.375*$100 = $68.75).

2.2.6 An insurer should work with the Authority to resolve any issues which may arise during the parallel run and phase-in periods. The Authority may subject the insurer to higher insurer-specific capital requirements, or take any other action, such as extending the parallel run or the cessation of new business for the product, if –

(a) the insurer has not fulfilled any of the conditions for exemption imposed by the Authority;

(b) the insurer fails to comply with paragraph 2.2.5; or

(c) the Authority subsequently becomes aware that the insurer has furnished material information that is false or misleading in connection with its application for the exemption.

2.2.7 As a condition of the exemption granted to the insurer, the Authority may require the insurer to notify the Authority of any change to an internal model as soon as possible, but not later than 1 month before the change takes effect, regardless of the insurer's view of the materiality of change. Upon notification, depending on the nature, scale and complexity of the change, the Authority may permit the insurer to make the change immediately, or request the insurer to make a new application for the exemption before the internal model can be used. Examples of changes for which the Authority may request of the insurer include, but are not limited to:

(a) changes in model inputs, parameters, assumptions[7] and methodologies that result in significant differences in liability and capital requirements;

(b) changes in organisational structure that affect controls on the use of the model and liability and capital calculations; and

(c) changes in the product offering that necessitate significant changes in the model inputs, parameters, assumptions and methodologies.

[7] For changes that are not entirely within the insurer's control, such as changes due to market movements, insurers are required only to notify the Authority as soon as practicable, rather than one month before the change.

2.3 INFORMATION REQUIRED FOR APPLICATION

2.3.1 For the purpose of paragraph 2.1.6, an application for the exemption should contain all of the following.

(a) A copy of the paper submitted for Board approval containing the details in paragraph 3.1.4 as well as an extract of the Board minutes documenting the Board's deliberations on the purpose, risks, limitations, policies, reporting requirements and use of the internal model, and the subsequent approval of the Board.

(b) A copy of the insurer's internal policies and procedures to address risk identification, measurement, monitoring, allocation, control and lines of responsibility associated with the product containing the details in paragraphs 3.2.1 to 3.2.8, where relevant. This should include the reporting structure, experience and qualification of personnel involved in the operation, review and approval of the model, including senior management. Any risk and exposure limit as contained in paragraphs 3.6.1 to 3.6.4 should be included.

(c) Where a model developed by a third party other than the insurer itself ("vendor model") is used, documentation as contained in paragraph 3.2.9 should be submitted.

(d) Documentation of the internal model encompassing the following details with sign-offs by the member of senior management with oversight responsibility of the internal model.

i. model development and validation as contained in paragraphs 3.4.1 to 3.4.8 and Appendix A; and

ii. details of the review (internal or external, details of the reviewer(s), tests or studies performed) performed by a party independent[8] from the model development process with regards to the methodology, development, operation and the accuracy and robustness of the output of the internal model, results of back-testing and stress-testing as contained in paragraphs 3.5.1 to 3.5.9.

(e) A written confirmation from a member of the insurer's senior management with oversight responsibility of the internal model that:

i. the insurer has conducted an internal assessment and has ascertained that it observes the Guidelines;

ii. the internal model forms an integral part of the risk strategy and operational processes of the insurer with regard to the product;

[8] For example, staff involved in the coding or assumption setting process is not deemed independent from the model development process.

iii. the insurer has ensured that senior management has overall control of and responsibility for the construction and use of the internal model and that the Board and senior management have sufficient understanding of the model's construction, outputs and limitations, in particular the implications on its liability and capital management;

iv. the insurer has a process for continually determining the suitability of its risk management framework, taking into account such regulations, notices and guidelines which the Authority may issue or change from time to time, and has submitted the documentation on the process to the Authority; and

v. the insurer has sound policies, procedures, systems and controls to calculate its liability and capital requirements for the product and that these policies, procedures, systems and controls are subject to internal audit or independent review on an annual basis;

(f) A written confirmation from a member of senior management responsible for the internal audit or independent review of the internal model that he agrees with the confirmation by the member of senior management with oversight responsibility of the internal model pursuant to sub-paragraph (e), and the insurer has conducted an internal audit or an independent review to verify, that it has the policies, procedures, systems and controls necessary for adopting the internal model.

(g) A report containing the latest internal assessment conducted by the insurer prior to the application as referred to in paragraph 1.1.6.

(h) The certification of the actuary appointed under section 31 of the Act that he/she has reviewed the applications and results of the internal model and has certified that they are appropriate for the determination of liability and capital requirements for regulatory purposes.

2.3.2 An insurer should submit sufficient details in its application for an assessment of the insurer's use of the internal model. As a guide, the documentation should be sufficient to enable an independent knowledgeable party to understand the design and specifications of the model and to replicate the model.

3 MINIMUM STANDARDS FOR USE OF INTERNAL MODEL

3.1 ROLE OF BOARD AND SENIOR MANAGEMENT

3.1.1 The Board should receive adequate training to ensure that it understands the nature and the level of risks taken by the insurer in offering a life insurance product with investment guarantees and how the risks fit with its overall business strategy.

3.1.2 The Board should ensure that senior management has the requisite skills to manage the risks arising from this product and the risks from the use of internal models to determine the liability and capital requirements of this product. The Board and senior management should also ensure that there is sufficient depth of risk management knowledge and experience across different levels and functions within the insurer.

3.1.3 The Board should ensure that clear and comprehensive written policies, procedures and controls relating to the use of the internal model are established. At the minimum, these policies should reflect the risk tolerance of the Board and clearly delineate lines of authority and responsibility for managing risk. The Board should also ensure that the actions of senior management are consistent with the policies, as part of checks and balances embodied in sound corporate governance.

3.1.4 The Board should approve the use of the internal model, and obtain the following information to satisfy itself that the risk management processes are adequate:

(a) Purpose of the internal model and documentation on integration of the internal model into the pricing and valuation processes of the company;

(b) Risks addressed by the internal model, for example, market, mortality, and lapse risks;

(c) Risk mitigating strategies to address the inherent risks of using the internal model, including controls to mitigate the risk of data-entry, programming and other errors;

(d) Limitations of the model;

(e) Policies on the level and limits of risks which the insurer is prepared to be exposed to, having regard to any risk mitigating strategies;

(f) Delegation of specific responsibilities to senior management who possess an appropriate understanding of the use of the model; and

(g) The opinion of the actuary appointed under section 31 of the Act on the appropriateness of the model, methodology, assumptions, and the adequacy of the resulting liability and capital levels.

3.1.5 The Board should also ensure that the risk management processes continue to remain adequate and relevant after the internal model has been assessed by the Authority. Senior management should articulate its expectations and provide guidance on technical and operational aspects of the risk management process and system with regard to the use of the internal model. In particular, senior management should verify that there are:

(a) Clear delineations of lines of responsibility for managing risk;

(b) Adequate risk measurement systems;

(c) Comprehensive set of risk limits, which should be relevant and specific to the product;

(d) Effective governance and internal controls;

(e) Effective risk reporting process that facilitates timely corrective actions to be taken; and

(f) Integration of the internal model into the overall risk management processes of the insurer, including the development and pricing of the product.

3.1.6 Senior management should ensure that a sufficiently frequent assessment process is established for ensuring compliance with risk management policies, procedures and controls, and that sufficient documentation of such assessment is in place.

3.1.7 Senior management should ensure that various components of the risk management process and systems of an insurer relating to the use of the internal model are regularly reviewed and evaluated. The review should be done at least on an annual basis and there should be proper documentation of such review. This review should take into account changes as a result of both internal and external events. For example, external events could include severe stresses in market conditions. Risk analyses pertaining to this product should be prepared monthly, where relevant, and reported to senior management.

3.1.8 Senior management should keep the Board informed of any weaknesses associated with the use of the internal model by the insurer on a regular and timely basis. The Board and senior management should also review the results and assumptions of any stress-tests conducted.

3.2 RISK MANAGEMENT PROCESS AND SYSTEM

Policies, Procedures and Controls

3.2.1 An insurer should establish policies to address the identification, measurement, assessment, monitoring and control of the risks associated with the product. The measurement of risk, its assessment, monitoring and control, should rest within a structure that is independent of the business function.

3.2.2 An insurer should ensure that the policies, procedures and controls are reviewed on a regular basis and kept relevant and up to date. The review should be done at least annually, and there should be proper documentation of such review. All risk policies, changes and exceptions to the policies should be approved by the Board.

3.2.3 An insurer should establish appropriate procedures to implement its risk policies. The insurer should also have a process in place for ensuring compliance with the documented set of internal policies, controls and procedures concerning the operation of the risk management process and system.

3.2.4 An insurer should ensure that its staff have ready access to the risk management documentation and are able to perform their respective risk management functions satisfactorily according to documented policies, procedures and controls. Individuals involved in the risk management process should not have conflicting responsibilities or priorities.

3.2.5 As model development and implementation is a complex process, an insurer should ensure that its staff have the requisite skills to manage the inherent complexity involved. The level of skills and experience of the key staff involved in the risk management functions for this product should be commensurate with the complexity of the risks they monitor.

3.2.6 Senior management of an insurer should ensure that the risk management policies, procedures and controls are clearly and comprehensively documented and communicated to the relevant staff. Senior management should also regularly evaluate the policies, procedures and controls to manage the risks and to ensure that these policies, procedures and controls are appropriate and sound.

3.2.7 Risk reporting and related analysis of the output from the internal model must provide senior management and the Board with information that permits them to assess the level of exposures being assumed, and should allow them to assess and evaluate the extent to which business risks of the product are within operational and capital limits.

3.2.8 An insurer should conduct a post-implementation review of the model at an appropriate time after its introduction. The insurer should maintain proper documentation of these reviews and take appropriate steps to address any issues that may arise from such reviews.

3.2.9 An insurer should not rely on the use of a vendor model that claims proprietary technology as a justification for exemption from the Guidelines. The insurer should instead, where necessary, place more reliance on alternative validation techniques or methods designed to compensate for the lack of access to full information. Where vendor models are used, the insurer should –

(a) Be able to document and explain the role of the vendor model and the extent to which it is used within the risk measurement system of the insurer;

(b) Be able to demonstrate a competent understanding of the vendor model, including the assumptions and limitations;

(c) Ensure that the vendor model is appropriate for measuring the risk posed by the product;

(d) Have clearly described strategies and policies for regularly reviewing the performance of the vendor model; and

(e) Have the model managed in-house to mitigate the operational risk arising from the insurer's reliance on the vendor to operate the model.

3.3 RISK MEASUREMENT

Overview

3.3.1 An insurer should ensure that its internal model includes all material risks posed by the product for example, mortality, lapse and market risks.

3.3.2 An insurer should relate its risk and exposure limits to its internal model in a manner that is consistent over time and well understood by senior management. The risk and exposure limits should be relevant and specific to the product.

3.3.3 Where the model is not developed in-house, the insurer should ensure that it understands the mathematical and statistical basis of the internal model.

3.3.4 Where the insurer has entered into a swap with a counterparty to hedge its risks posed by this product, the insurer may recognise the market value of the swap as an asset on its balance sheet. The insurer should not take any credit for the swap when calculating its liability and C1 and C2 duration mismatch risk requirements.

3.3.5 The Authority reserves the right to set guidelines different from those stated in the Guidelines. An insurer which has already launched its products should observe with such new guidelines within a timeframe as set out by the Authority.

3.4 MODEL VALIDATION

Overview

3.4.1 An insurer should have policies and processes in place to ensure that its internal models are adequately validated by suitably qualified parties with satisfactory educational qualification and experience, and relevant skills and knowledge, who may or may not be external parties, but who are independent of the development process[9] to ensure that the models are robust and adequately capture all risks posed by the product to the insurer.

3.4.2 The insurer should conduct a model validation when the model is initially developed, when any significant change is made to the model and at least on an annual basis. More frequent validation should be conducted if considered necessary, given the nature of the risks posed by the product. The validation report should be submitted to the Authority as required in part 2.3. Where necessary, the insurer should calibrate the model and inform the Authority of the recalibration. An insurer should take into account academic and market development as part of its regular model review process, and ensure that any significant issue is escalated to senior management and promptly addressed.

3.4.3 Where an insurer has outsourced its validation function to an external party, it should have qualified staff independent of the development process to assess the quality of work done by the external party in validating the model. The insurer is ultimately responsible for all model validation work which should be endorsed by the Board and senior management.

Model Validation Policies

3.4.4 The insurer should have model validation policies which include the following elements:

(a) Model Approval Process:

i. Validation personnel should have the necessary experience and expertise;

ii. The responsibilities of these personnel should include ensuring that the current systems set-up is capable of supporting the model;

iii. All changes made to the models being used, or to the modelling process, should be validated and approved;

iv. The insurer should maintain previous versions of the model being altered; and

v. Models should be subject to change-control procedures, so that computer codes cannot be changed except by authorised staff;

[9] Any person who is involved in, or who reports to any person who is involved in the design or construction of the model cannot be regarded as an independent party for this purpose, or for the purposes of testing the model and conducting an independent review of the model.

(b) Defined Responsibilities:

i. The responsibilities for model construction and model validation should be clearly and formally defined;

ii. The personnel performing model validation should be independent of the personnel who designed or constructed the model (i.e. the insurer should ensure that there is no conflict of interest and that the personnel performing the validation work can provide objective and effective challenge to the personnel who designed or constructed the model);

iii. The personnel (whether in-house or external) responsible for model validation should ascertain that the model is robust and suitable for its proposed usage, before the model can be used; and,

(c) Documentation on model methodology, statistical basis, and key assumptions (For more details on the information to be included in the technical documentation for this part, please refer to Appendix A).

Model Validation Process

3.4.5 The insurer should have a model validation process which addresses at least three components of the model:

(a) A model inputs component, which delivers data and assumptions to the model;

(b) A model processing component, which encompasses the theoretical model and the computer codes which transform the model inputs into mathematical estimates; and

(c) A reporting component, which translates the mathematical estimates into useful business information.

3.4.6 In validating the model inputs component, an insurer should –

(a) Ensure that data from both internal and external sources are consistent, timely, reliable, independent and complete;

(b) Have filter and inspection procedures to surface potential data errors, which should be verified with an alternate data source;

(c) Automate the extraction of data to the extent possible. As manual extraction of data is error-prone, the insurer should pay more attention to validating such data;

(d) Ensure that all data required for risk measurement are captured by the internal model;

(e) Ensure that assumptions [10] required to model the risks involved are appropriately derived and justified, and do not underestimate risk; and

(f) Check its assumptions periodically, to ensure that they do not diverge from observed behaviour.

3.4.7 In validating the model processing component, an insurer should-

(a) Validate all models[10], whether they are purchased from a vendor or developed in-house, to ensure the accuracy of model outputs. The insurer should not rely solely on a model validation done by the vendor;

(b) Apply procedures to test the programmed model and the mathematics used against the functional specifications of the model; and

(c) Use hypothetical portfolios to ensure that the model is able to account for structural features which may arise, including –

i. Where the insurer maps positions to proxy data, ensuring that the proxy data produces conservative results under relevant scenarios;

ii. Ensuring that significant basis risks are adequately captured. This may include mismatches between long and short positions by maturity or by issuer, where applicable; and

iii. Ensuring that the model captures concentration risk which may arise in an undiversified portfolio, where applicable.

3.4.8 In validating the reporting component, an insurer should:

(a) Ensure that senior management understands the context in which the model results are generated; and

(b) Have a system of checks to ensure that the flow of information from the model outputs to the final production of the reports is error-free.

3.5 RISK MONITORING

Overview

3.5.1 An insurer should provide the Board, senior management and where appropriate, individual business unit managers with reports on a regular and timely basis. These reports should include comparisons of risk taken against the corresponding limits.

3.5.2 If exposure to the product is material, the insurer should also ensure that the Board is given a report at least annually on the extent to which the insurer has been effective in managing its risks posed by this product and has complied with its risk management policies, controls and procedures.

[10] This should include the validation of policy owner behavior such as dynamic lapses.

Independent Review

3.5.3 An insurer should have a review team which is independent of the business functions. Staff should not be involved in the review team if they have been involved in the model development activities in the preceding 12 months. This team should be staffed with personnel with a competent understanding of the use of the internal model. This may be the insurer's Internal Audit department, if it has the relevant expertise.

3.5.4 An insurer should carry out an independent review of its risk management process and system regularly as part of its own internal audit process, and this review should include the product as well as the use of the internal model. The insurer should carry out the review at least once annually, and the review should cover, at a minimum, the following areas:

(a) Adequacy of the risk management process and system as well as its documentation;

(b) Review of reports from the portfolio manager such as daily risk report, stress tests and attribution reports;

(c) Integration of risk measures into daily risk management of the product;

(d) Approval process for the risk pricing and valuation models;

(e) Validation of significant change in the model and risk management process;

(f) Scope of risks included in the internal model and their sufficiency as well as the mathematical and statistical basis used to model these risks, and the methodology as well as underlying assumptions;

(g) Verification of the consistency, timeliness, and reliability of data sources used to run internal models, including the independence of such data sources;

(h) Appropriateness of volatility and correlation assumptions; and

(i) Verification of the accuracy of internal models through comparison against actual market performance.

3.5.5 The insurer should increase the depth and frequency of internal audits if significant issues are discovered, or if significant changes have been made to product lines, modelling methodologies, the risk oversight process, and internal controls regarding the product.

Back-Testing

3.5.6 Back-testing is the process of comparing historical results to those produced by the current model. It validates both the reasonableness and the implementation of the assumptions. Insurers should carry out back-testing at least on a quarterly basis and be able to justify the methodology used to do the back-testing[11]. There should be an ongoing analysis of changes in modelled results from one period to the next. Where back testing is not practical, a review of projected results from the model versus reasonable proxies or benchmarks, such

[11] Depending on the specific product feature, however, the Authority may allow the insurer to conduct back-testing and stress testing on a less frequent basis, such as annually.

as recent history, adjusted for inflation, growth etc., or business plans is an alternative. The insurer should be aware of the limitations of the use of proxies and benchmarks and institute mitigating actions where appropriate.

Stress-Testing

3.5.7 An insurer should have in place a rigorous and comprehensive stress-testing framework in relation to its use of the internal model. Stress-testing should be reviewed regularly by both the Board and senior management, and used as a means of setting its policies and limits, under both stressed and normal business conditions, and for monitoring products where no historical data may be available. Insurers should carry out stress-testing at least on a quarterly basis[11].

3.5.8 An insurer should incorporate into the stress-testing scenarios single and multiple events, both quantitative and qualitative, and capture all material market and insurance risks to which the insurer is exposed with regards to such products, including policy owner behaviour and market liquidity. Sufficiently adverse events must be captured within these scenarios. As an example, a significant market downturn with little or no recovery for a number of years should be tested. The insurer should include the reasons for selecting the scenarios and justify how the scenarios are sufficiently severe to meet the calibration criteria set out in paragraph 2.2.1.

3.5.9 For scenarios that exhibit vulnerabilities, an insurer should initiate a discussion between the Board and senior management of appropriate management actions. Such actions should focus on risk reduction and capital preservation. If possible, the actions should also be modelled to quantify their effects.

3.6 RISK CONTROL

3.6.1 An insurer should have in place a comprehensive set of risk limits to align its business goals with its risk threshold and to set boundaries on its risk-taking with respect to the product. The limits should be well-documented and consistent with the effectiveness of the overall risk management process and systems of the insurer and the adequacy of its capital levels. The limits should also be relevant and specific to the product. Appropriate limits would allow the insurer to control exposures, to initiate discussion about opportunities and risks, and to monitor actual risk-taking against pre-determined tolerances.

3.6.2 An insurer should ensure that its Board and senior management establish, approve and review the limit structure and high-level risk limits for this product at least annually. The insurer should re-assess its limits when there are changes in market conditions or its capital resources.

3.6.3 The review of the limit structure should compare limits to actual exposures and should consider whether existing measures of exposures and limits are appropriate in view of past performance and existing capital levels of the insurer.

3.6.4 An insurer should establish procedures prescribing the course of action for limit excesses for this product. These procedures should include the actions required for the approval of temporary excesses and limit increases, the investigation of the reasons for the infringement of the limits and escalation of limit excesses to management.

APPENDIX A – MINIMUM STANDARDS ON TECHNICAL DOCUMENTATION

Guiding Principle

1 An insurer should ensure that the information provided in the technical documentation is sufficiently detailed so that the Authority is able to make an assessment of the insurer's use of the internal model. As a matter of principle, the documentation should be sufficient to enable an independent knowledgeable party to understand the design and specifications of the model and to independently replicate the model.

2 As a general guide, an insurer should include in the technical documentation a discussion of the various issues as listed in the paragraphs below. However, an insurer should not take this appendix as an exhaustive checklist to be satisfied for assessment by the Authority.

General Issues

3 Model purpose and use: The technical documentation should incorporate a description of the following:

(a) Purpose of the model: An insurer should indicate whether the model is a partial model only for the purposes of simulating the underlying asset classes to which the investment guarantee is linked, or if it is a full model intended for the purposes of deriving the liability and capital requirements of the product. In the former case, the insurer should still describe and explain how the liability and capital requirements of the product are derived;

(b) Scope of the model: An insurer should indicate if the model is intended to be used only for the product in question, or if it is to be used for more than one product. If the model is to be used for more than one product, the insurer should advise the Authority of any adjustments made, where relevant in extending the model;

(c) Linkages: The general linkages between the inputs, the processing stage, the outputs – both intermediate and final. Process diagrams can be included if the insurer feels that doing so would add further clarity.

4 Model applications and integration: An insurer should describe how the outputs of the model are incorporated into the pricing and other risk management processes of the insurer, such as the development of tolerance limits, internal capital allocation, and internal reporting. Insurers should also describe the organisational structure responsible for the development, operation (including assumption setting), review, approval and interpretation of the model and how this relates to the overall risk management and business structure of the company. In this respect, the insurer should provide its internal policy documents which set out principles and standards for the mitigation of model risk. This document should describe the procedures that the institution requires to be followed for developing, maintaining and using the internal models.

Model Construction

5 Product description: Product features should be consistent with the risk factors being modelled as well as the underlying assumptions on the model. An insurer should therefore provide a comprehensive description of the product for which the model is intended.

6 Underlying mechanism: In providing exposure to various asset classes, for instance, equity indices, an insurer may have several options, such as investing in these classes directly, entering into a total return swap with an investment bank, etc. The underlying mechanism behind the product should be clearly described in the technical documentation. For instance, if the various indices are to be held in a certain proportion, the technical documentation should include a description of the mechanism and cost of rebalancing.

7 Risk factors: The modelling process should encompass a mapping of the various asset classes to the pertinent risk factors (such as duration, general/specific equity risk, foreign exchange risk, counterparty risk where the underlying is a swap, etc). An insurer should clearly identify the risk factors in the technical documentation, to enable the Authority to identify if the mapping process and identification of risk factors is comprehensive. If a risk factor which is pertinent to the process has been intentionally omitted, the insurer should include reasons why that particular risk factor has been omitted. For instance, if an insurer is modelling the equity returns of various global indices denominated in Singapore dollars, the Authority would expect one of the risk factors to be modelled to be foreign exchange risk. Insurers which omit foreign exchange risk would have to include an explanation of why this risk factor is omitted.

8 Model points: Where model points are used, an insurer should explain the grouping criteria used (for instance, the class of policy, duration in force, outstanding term, how close guarantees are to being in the money, etc.). The use of model points to represent groups of homogeneous policies in place of a policy-by-policy approach are allowed, but the insurer will need to conduct regular tests to ensure that they are appropriate and will not understate the regulatory liabilities and capital requirements.

9 Mathematical and statistical basis of the model: An insurer should describe in their technical documentation the mathematical and statistical basis of the model, for instance, whether equity returns are modelled based on a lognormal distribution, regime switching lognormal process or generalised autoregressive heteroskedastic model (“GARCH”) etc., and the rationale for choosing the particular distribution.

10 Key assumptions: The output of a model is frequently dependent on the interplay of several risk factors, as well as other variables. Where some of the variables require assumptions (whether deterministic or stochastic), an insurer should clearly state and justify these assumptions. An insurer should also describe and explain techniques used to model assumptions such as policy owner behaviour/dynamic lapse assumptions and for returns in asset classes with low liquidity. In particular, the insurer should account for the following issues in its documentation:

(a) Dependency of assumptions: Some assumptions, such as assumed rate of take-up of options/dynamic lapse assumptions, are sometimes treated as independent variables and sometimes as dependent on the underlying economic variables. For example, policy owner behaviour can strongly influence the amount of cash that can

be invested or need to be disinvested in any particular period. For these products, variations in policy owner behaviour are an important consideration that should be accurately reflected in the model. For instance, lapse assumptions should take into account policy owner behaviour. If the results of the asset cash flows are calculated without reflecting the variation in cash flows caused by policy owner behaviour, the model may produce inaccurate information. The insurer should explain the dependence structure among all the assumptions to enable the Authority to assess the structure of the model;

(b) Basis of assumptions: An insurer may draw its assumptions from many sources, including its own experience, industry data and/or reinsurer's data. The insurer should document how it derived its assumptions from these sources, where relevant. Where there is considerable uncertainty even in the best estimate assumption, the insurer should indicate and justify the level of margins in the assumptions.

11 Model methodology: An Insurer should give a detailed description of the methodology used in the model, including:

(a) Choice of parameters for the model: The insurer should include a detailed commentary on the choice and derivation of the parameters for the model, for instance, the volatility of the underlying assets;

(b) Time horizon used in the projection: In theory, the time horizon for projection should be the period over which the adverse experience is expected to occur. In practice, the selection of an appropriate time horizon may vary by the specific use of the internal model. In some cases, the time horizon is set according to accepted reporting practice at some reasonable time frame during which management action is expected, and/or the frequency of financial reporting. In other cases, the time horizon is set to longer periods or even the entire lifetime of the risks, especially if the impact of these risks take a few years to fully emerge (for example, product guarantees). The insurer should therefore justify its choice of the time horizon. Where the lifetime of the risks are longer than the time horizon used for projection, the insurer should therefore explain how the liability and capital requirement for these remaining risks are calculated and accounted for, for example by the calculation of a terminal provision.

(c) Time granularity: Time granularity is concerned with the length of the interim periods that make up the overall period in which the modelled events are expected to occur. The calculation of the cash flows is pegged to these interim periods. For instance, an insurer may choose to calculate its investment guarantees and liability requirements on a monthly basis even though its projection period is a much longer period, for instance, 25 years. The insurer should relate its choice of the interim period to the frequency with which the investment guarantees are set, since the use of a longer interim period is essentially equivalent to making greater approximations.

(d) Number of Simulations: An insurer should include the results of any convergence test to justify the number of simulations/scenarios used to ensure that the distribution produced is sufficiently reliable and stable. The stability and reliability of the distribution produced should be demonstrated by empirical testing.

(e) Scenarios Chosen: An insurer should provide a description of the scenarios used (especially for stressed scenarios) and justify why the scenarios are suitable or sufficiently stressed.

(f) Correlation matrices: In modelling the value of investment guarantees embedded in the product, where such guarantees are related to price movements of the underlying assets, an insurer should recognise empirical correlations within risk factor categories (e.g. interest rate, equity prices, foreign exchange and commodity prices). The insurer should also recognise empirical correlations across risk factor categories. In situations where correlations cannot be reasonably determined, conservative assumptions should be used. The insurer should provide an explanation of:

i. Correlation coefficients chosen: for example, whether it is derived from historical data, and if so, the relevance of the time period chosen, or whether it is determined stochastically so that it will vary according to the time period and the underlying assumptions of that stochastic simulation and a justification of the methodology used;

ii. Robustness of the correlation coefficients selected – the insurer should include a validation of the correlation matrices chosen – whether it is by comparison against historical correlations in certain time periods or by other methods, and to ensure that the correlations encompass all relevant risk factors. To use the same example as earlier, correlation matrices of the different equity indices should encompass correlations between foreign exchange returns as well as equity returns, and not just the latter;

iii. Techniques used to adapt their models to simulate correlated variables. For instance, if cholesky factorisation is used, the insurer should be able to justify that all the assumptions underlying the use of this method are satisfied: i.e., that the number of risk factors is small relative to the number of assets in the portfolio, the correlation is not measured over different time periods where distributional parameters could change (stationarity), and the series are not linear combinations of others (for e.g., a currency basket). If one of these conditions are not satisfied, the insurer should include a documentation of the methods used to address the problem of not meeting the stated assumption underlying the method.

(g) Random number generator: Random number generators require an initial number as “seed” to produce the next number. In designing and operating a stochastic model, it is essential to retain the value of the initial random number generator seed used in each simulation and store this with the results of the simulation. This will enable the models to be re-run for de-bugging and audit purposes. Generators, being algorithms, normally are cyclic in nature so that the values drawn will repeat after sufficiently many values have been drawn. If the number of random numbers required exceeds the period of the generator, the numbers can no longer be considered to be truly random and the simulation would be flawed. An insurer should thus include an assessment of the random number generator used in their model in the technical documentation.

(h) Input data: In using historical data to develop parameters for the model, an insurer should document its considerations with regard to the use of data. More specifically, the insurer should include a consideration of the issues below:

i. Limitations of historical estimates: Values from historical data must be adjusted going forward as economic, political, regulatory and technological environments change. These regime changes may result in non-stationary data. Using too long a span of data may include data which is no longer relevant if there have been regime changes. However, a shorter span of data may decrease the precision of population parameter estimates and lead to less stability in the mean returns, standard deviations and correlations. The insurer should therefore justify the choice of the time span used and ensure that it has tested the data to avoid any time period bias.

ii. Measurement errors and biases: An insurer should be aware of measurement errors and biases in the data, such as survivorship bias. As an example, a return series based on a stock index will be biased upwards if the return calculation does not include firms that have been dropped from the index due to delistings.

12 Weaknesses of the model and mitigation measures: Many of these models may have inherent weaknesses, for instance, the simple lognormal distribution may not be able to effectively model the leptokurtic nature of actual stock returns. An insurer would have to identify the weaknesses of the model chosen and how it has mitigated this weakness in its modelling process.

13 Output of the model: An insurer should include summary statistics generated by the model, including the key risk metrics such as the liability and capital requirements generated by the model which would satisfy the minimum quantitative standards. Where an insurer finds that the product is susceptible to certain key adverse scenarios, it should describe such scenarios and its capital implications as well as any risk management processes implemented to mitigate this tail risk.

14 Operation of model: Descriptions of the business processes, model process diagrams as well as operational instruction manuals to staff (detailed run instructions to staff, the purpose, procedural steps and the expected outputs) should be included where the insurer feels that this will make the process clearer to the Authority for assessment purposes.

15 Log of all activities related to the construction or alteration of the model, including the decisions ultimately taken: If more than one model was used, the insurer should include the log for all models.

16 Description of key staff designing and operating the model: An insurer should include the names of the members of the team, their experience, and qualifications in designing and operating the model, as well as their reporting lines, roles and structures in the technical documentation.

Model Validation

17 In assessing the robustness of the model, the Authority will consider the validation of the model by the insurer, including regression analysis, measures used to assess model quality such as "goodness-of-fit" measures, stress-testing, the scope of testing, the number of tests completed and the results of these tests. If the results are unclear, or the testing of the model by the insurer is deemed insufficient to conclude that the model is robust, the insurer should address these issues before the Authority reassesses the model for the exemption applied for by the insurer.

18 Description of validation procedures and test results: In carrying out a validation of the model and its use, an insurer should ensure that the following issues are validated and documented:

(a) Conceptual issues: An insurer should ensure that the validation process considers the following:

i. Adequacy of coverage of the model with regard to the risks posed to the insurer by the product;

ii. Product design and assumptions: the insurer should validate that the product design, pricing and other assumptions (such as on inflation, dynamic lapse, etc) and methodologies have been implemented in a manner consistent with the approach with their pricing documentation as well as other internal guidance it may have;

(b) Implementation issues: In terms of validation of implementation, the insurer should ensure that the validation process for the following has been adequately detailed:

i. Model inputs, processing and reporting: The insurer should ensure that the validation process takes into account the Guidelines from paragraphs 3.4.5 to 3.4.8. For instance, the insurer may choose to carry out convergence tests to evaluate the minimum number of scenarios which it has to run, validate component calculations, add complexity incrementally, compare against other models, examine the various levels of aggregation, change the assumptions and evaluate the output of the model, etc. Whatever the process or methods chosen should be clearly explained and justified and the results stated;

ii. User-defined formulae used in the model are accurate;

iii. Automated batch processes used by the model are accurate and produce the required results; and

iv. Data Integrity and procedures to ensure that data from both internal and external sources are consistent, timely, reliable, independent and complete.

(c) Back-testing, Sensitivity and Stress Tests: An insurer should include details of the tests undertaken, the rationale for its choice and the results and implications of any sensitivity and stress tests, including the sensitivity of results to key parameters.

19 Description of key staff validating/reviewing the model: An insurer should include the names of the members of the team, their experience and qualifications, as well as their reporting lines, roles and structures.