舞台設備SIL3安全認證---兩廳院案例分享講座

SIL 3系統的定義：

一個**功能安全完整性等級3**的系統簡稱為SIL3系統，是帶有SIL3的安全儀表系統（包含硬體與軟體控制）的電氣/電子/可程式電子安全相關系統。

功能安全作為一個術語和工程學科，是隨著複雜可編程電子學的發展而出現。

Picture By Mascamon at Luxembourgish Wikipedia

例如在一個舞台鍊條吊車的馬達中加裝溫度感測器，若溫度超過一定值，即停止馬達運轉，此機能就屬於功能安全。

又如在每台舞台鍊條吊車與建築結構之間加裝載重測量器，當使用多台鍊條吊車並設定為一個群組懸吊一組LED屏幕時，如果某台吊車的載重超過一定值，舞台設備控制系統會立刻啟動E-Stop，停止所有相關舞台設備的動作。

舞台設備SIL3安全認證---兩廳院案例分享講座

安全完整性等級（Safety Integrity Level，簡稱SIL）是功能安全的一部份，定義為由於安全功/機能所降低風險的相對水準，或是風險降低後，風險的相對水準。簡單來說，安全完整性等級就是度量安全儀表系統所需要的性能。

歐盟即將採用德國“娛樂業舞台和製作設施”標準（DGUV 17/18），規定在任何人的上方移動表演人員、布景、燈架等舞台設備系統必須達到 SIL3。SIL3對達到SIL3認證的零件要求的失效概率約為1000年內允許失效1次。如果一個舞台安全控制系統有 100個SIL3組件，整個系統的失效機率降到10年內一次。因此定期的整套系統SIL3認證也非常重要。

舞台設備SIL3安全認證---兩廳院案例分享講座

講師：Christoph Meyer-Stumborg

資格：

- VBG 德國（國家）保險公司授證的“娛樂業舞台和製作設施”
  安全認證專家（DGUV 17/18 [原稱 BGV C1] + DGUV G 315-390）
- 機械安全專家（2006/42/EC + DIN 56950-1/2/3/4）
- 功能安全專家（EN 61508-1 ... 7）
- 控制系統與自動化專家
- 健康、安全與環境管理（HSE）專家（根據DGUV V2§4（2）批准的安全工程師）
- 健康、安全與環境管理（HSE）現場專家（根據德國法規RAB 30部分B + C）
- 施工架專家（根據德國法規TRBS 1203 + TRBS 2121第1部分）
- 德國工商聯合會（IHK）健康、安全與環境管理（HSE）培訓師

經歷：

- 超過20年的娛樂業舞台與製作設施、舞台機械控制與自動化經驗
- 4年VBG 德國（國家）保險公司授證的“娛樂業舞台和製作設施”安全認證專家資歷

Ingenieurbüro Q3

Safety of Machinery 機械安全

+

Functional Safety 功能安全

An Introduction 介紹

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V1.8

Safety of Machinery + Functional Safety 機械安全+功能安全

Ingenieurbüro Q3

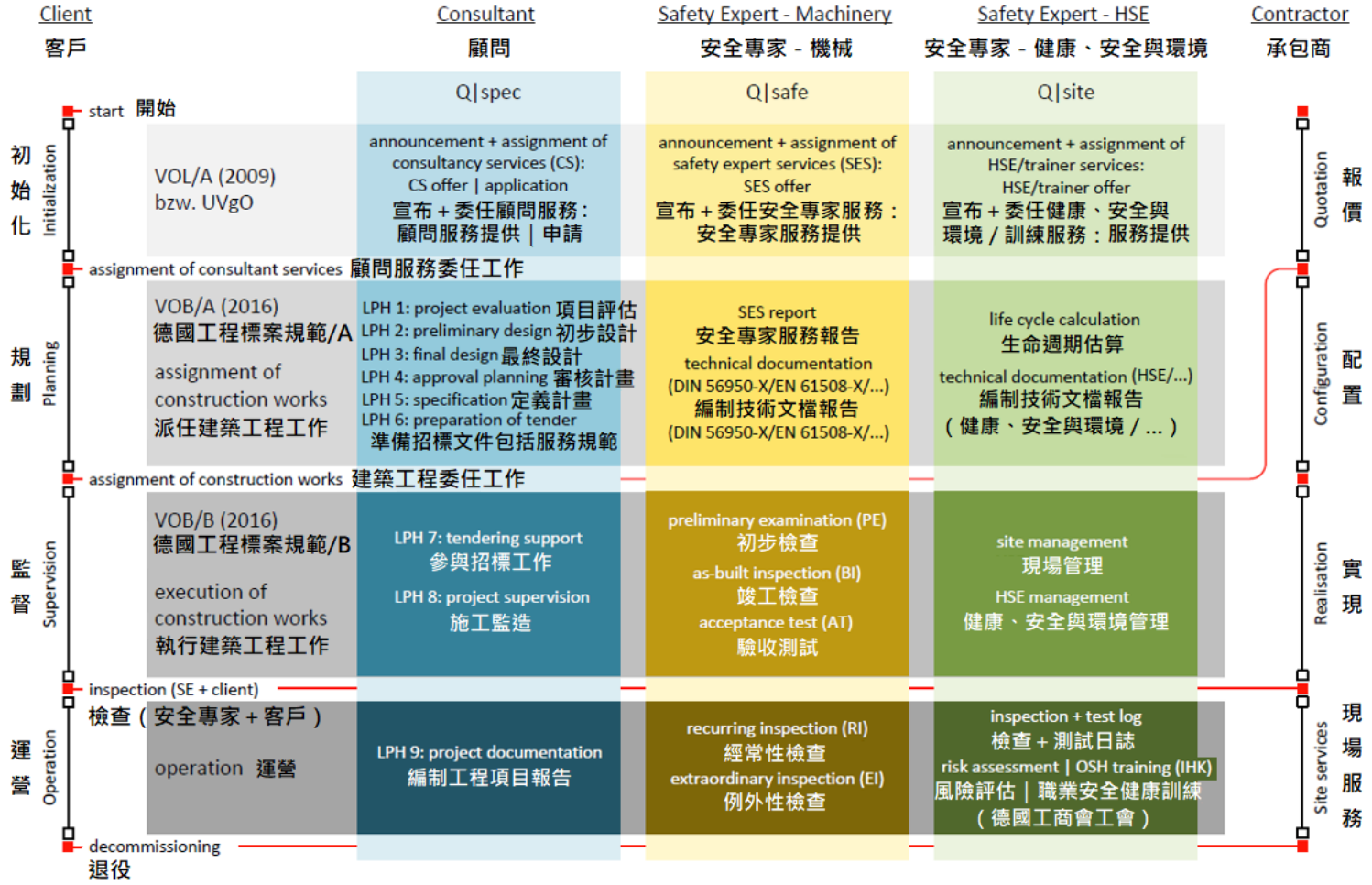
Engineering Office Q3 服務項目

- Christoph Meyer-Stumborg
- Electrical Engineer 電機工程師

- Founded 2013 成立於2013年
- Since 1997 working in entertainment business 1997年以來工作於表演娛樂產業

- Consultant 顧問
- Safety Expert – Machinery
  安全專家 – 機械
- Safety Expert – OHS/HSE
  安全專家 – 職業安全與健康/健康、安全與環境

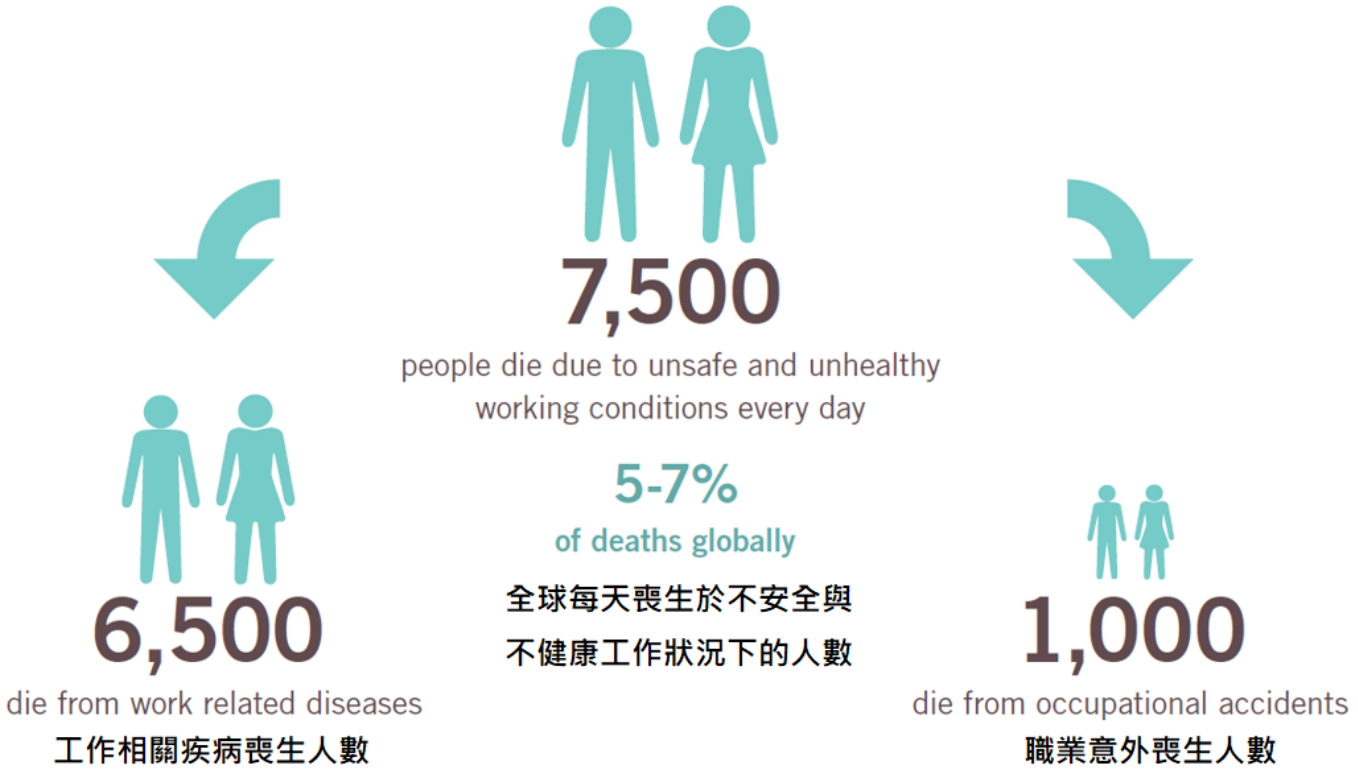
- www.triple-Q.de



Safety of Machinery + Functional Safety 機械安全+功能安全

Ingenieurbüro

OSH - Occupational Safety and Health | Today's picture OSH - 職業安全與健康| 現況



Source: ILO Report (2019) - SAFETY AND HEALTH AT THE HEART OF THE FUTURE OF WORK 來源：國際勞工組織報告（2019年） - 未來工作的重心：安全與健康

Safety of Machinery + Functional Safety 機械安全+功能安全

Ingenieurbüro Q3

OSH - Occupational Safety and Health | General principles OSH - 職業安全與健康| 一般性原則

1. Avoid hazards wherever possible 盡可能在各處避免危險
2. Keep the residual risk as low as possible 盡可能保持低的剩餘風險
3. Dangers are to be tackled at their source (→ inherently safe design measures) 應從源頭解決危險（→本質上安全的設計措施）
4. Measures: Consideration of state of the art, occupational medicine, hygiene, ... 措施：考慮最新技術、職業醫學、衛生……
5. Measures: Linking technology, work organization, other working conditions, ... 措施：連結技術、工作組織、其他工作條件……
6. Individual protection measures are subordinate (→ personal protection equipment) 個人保護措施是從屬的（→個人防護設備）
7. Appropriate instructions + trainings must be given to the users 必須提供使用者適當的說明+培訓

Safety of Machinery + Functional Safety 機械安全+功能安全

Ingenieurbüro Q3

Standardization – Organizations 標準 – 組織

	Germany 德國	Europe 歐洲	International 國際	
non-electrical technologies 非電機技術	DIN	cen	ISO	ISO International Standardization Organization 國際標準化組織
electrical engineering 電機工程	DKE VDE DIN	CENELEC	IEC	IEC International Electrotechnical Commission 國際電工委員會

Safety of Machinery + Functional Safety 機械安全+功能安全

Ingenieurbüro Q3

Structure of international standards 國際標準結構

type-A standards (basic safety standards) giving basic concepts, principles for design and general aspects that can be applied to machinery; → ISO 12100:2010 → IEC 61508-1 … 7:2010 A類標準（基本安全標準），提供可應用於機械的基本概念，設計原則和一般方面; →ISO 12100：2010→IEC 61508-1 … 7：2010

type-B standards (generic safety standards) dealing with one safety aspect or one type of safeguard that can be used across a wide range of machinery: B類標準（通用安全標準）涉及一種安全方面或一種可用於各種機械的安全措施：

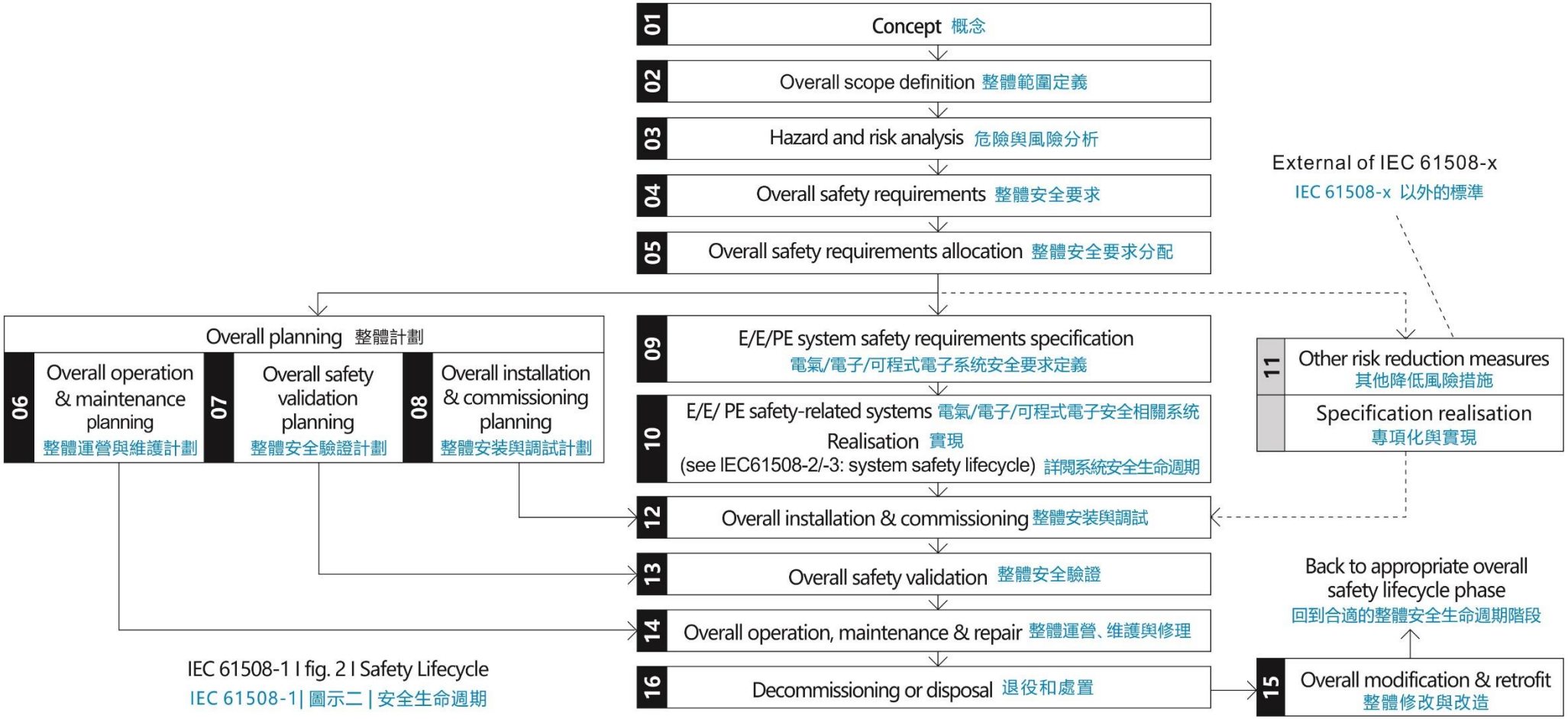
- type-B1 standards on particular safety aspects (for example, safety distances, surface temperature, noise); 關於特定安全方面的B1類標準（例如安全距離、表面溫度、噪音）;
- type-B2 standards on safeguards (for example, two-hand controls, interlocking devices, pressure-sensitive devices, guards); 關於安全措施的B2類標準（例如雙手控制、聯鎖裝置、壓敏裝置、防護裝置）;

type-C standards (machine safety standards) dealing with detailed safety requirements for a particular machine or group of machines. → DIN 56950-1:2012 → prEN 17206:2018 C型標準（機械安全標準），處理特定機械或機械組的詳細安全要求。 →DIN 56950-1：2012→prEN 17206：2018

Safety of Machinery + Functional Safety 機械安全+功能安全

Ingenieurbüro Q3

Agenda 議程



Safety of Machinery + Functional Safety 機械安全+功能安全

Ingenieurbüro Q3

Agenda 1|4 議程 1|4

Safety of machinery 「機械安全」

General principles for design - Risk assessment and risk reduction

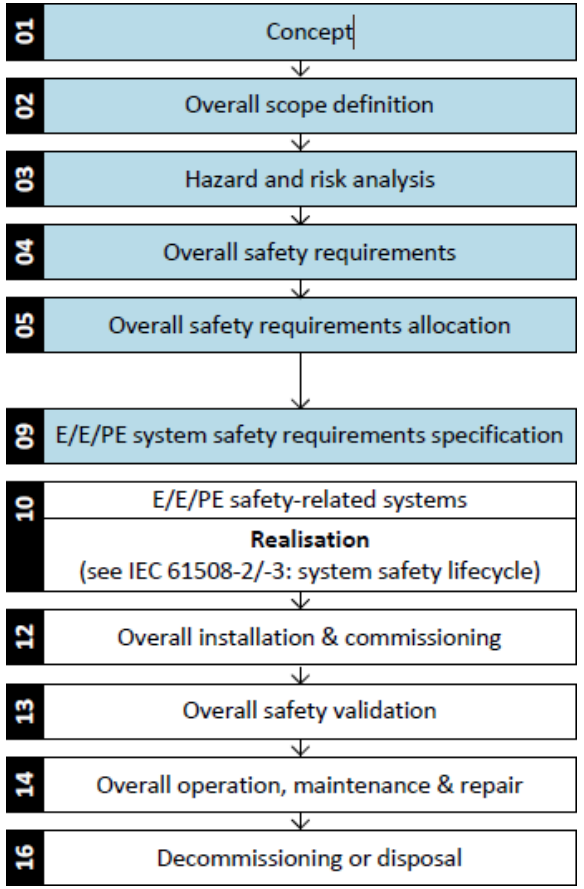
設計的一般原則 - 風險評估和降低風險

→ ISO 12100:2010

Functional safety of electrical/electronic/programmable electronic safety-related systems (E/E/PES)

電氣/電子/可編程電子安全相關系統的「功能安全」

→ IEC 61508-1 … 7:2010



Safety of Machinery + Functional Safety 機械安全+功能安全

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Safety of machinery - General principles for design - Risk assessment/reduction

機械安全 - 設計的一般原則 - 風險評估/減少

Concept of safety of machinery 機械安全的概念

→ the ability of a machine to perform its intended function(s) →機器執行其預期功能的能力

→ during its life cycle →在其生命週期中

→ where risk has been adequately reduced →風險已經充分降低

IEC 12100 provides **guidelines** about how to obtain a safe machine or equipment under control

IEC 12100提供了有關如何獲得安全機器或受控制設備的指南

Strategy: 策略：

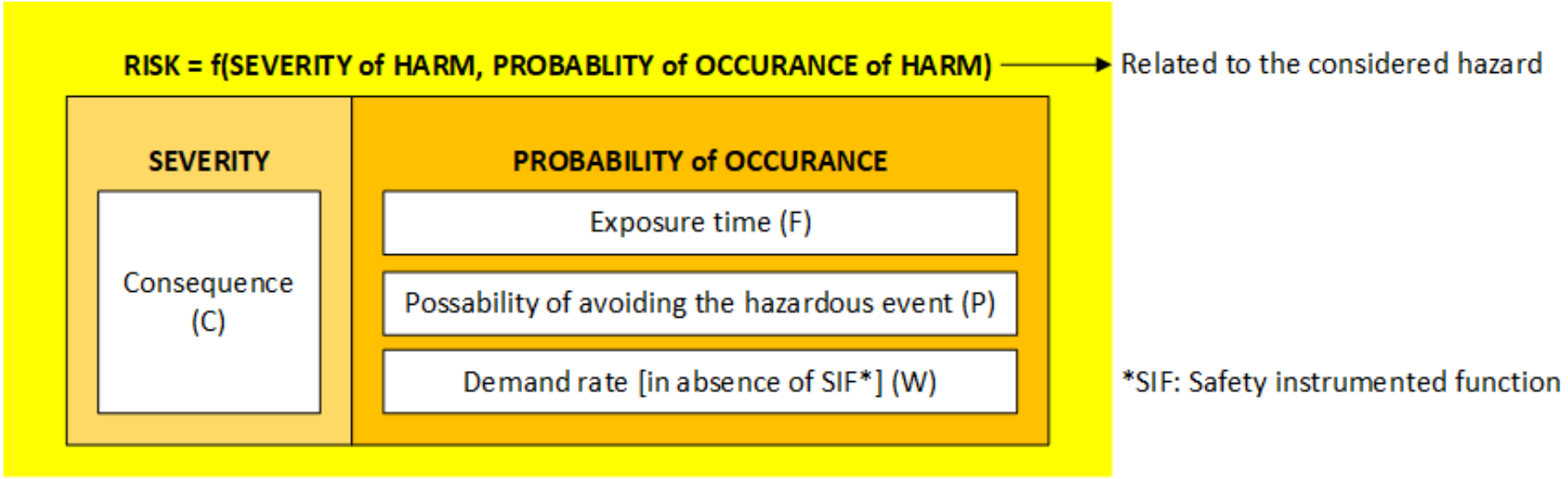
1. **Risk Assessment** 1.風險評估
2. **Risk Reduction** 2.降低風險

Safety of machinery - General principles for design – “Risk”

機械安全 - 設計的一般原則 - “風險”

From a machinery perspective, ISO 12100:2010 defines risk as: 從機械角度來看，ISO 12100：2010將風險定義為：

“combination of the **probability of occurrence** of harm and the **severity** of that harm “傷害發生概率與傷害嚴重程度的組合”



Safety of machinery - General principles for design – “Hazard”

機械安全 - 設計的一般原則 - “危險”

From a machinery perspective, ISO 12100:2010 defines **hazard** as: 從機械角度來看，ISO 12100：2010將危險定義為：

“potential source of harm” “潛在的傷害來源”

Note 1: The term “hazard” can be qualified in order to define its **origin** (for example, mechanical hazard, electrical hazard) or the **nature** of the potential harm (for example, electric shock hazard, cutting hazard, toxic hazard, fire hazard). 注1：“危險”一詞可以限定其來源（例如機械危險、電氣危險）或潛在危害的性質（例如觸電危險、切割危險、毒性危害、火災危險）。

Note 2: The hazard envisaged by this definition either 注2：該定義所設想的危險

- is **permanently present** during the intended use of the machine (for example, motion of hazardous moving elements, electric arc during a welding phase, unhealthy posture, noise emission, high temperature), or 在機器的預期使用期間永久存在（例如危險運動元件的運動、焊接階段的電弧、不健康的姿勢、噪音、高溫），或者
- **can appear unexpectedly** (for example, explosion, crushing hazard as a consequence of an unintended/unexpected start-up, ejection as a consequence of a breakage, fall as a consequence of acceleration/deceleration). 可能出現意外情況（例如爆炸、由於意外/意外啟動造成的擠壓危險、由於破損導致的彈射、由於加速/減速而下降）。

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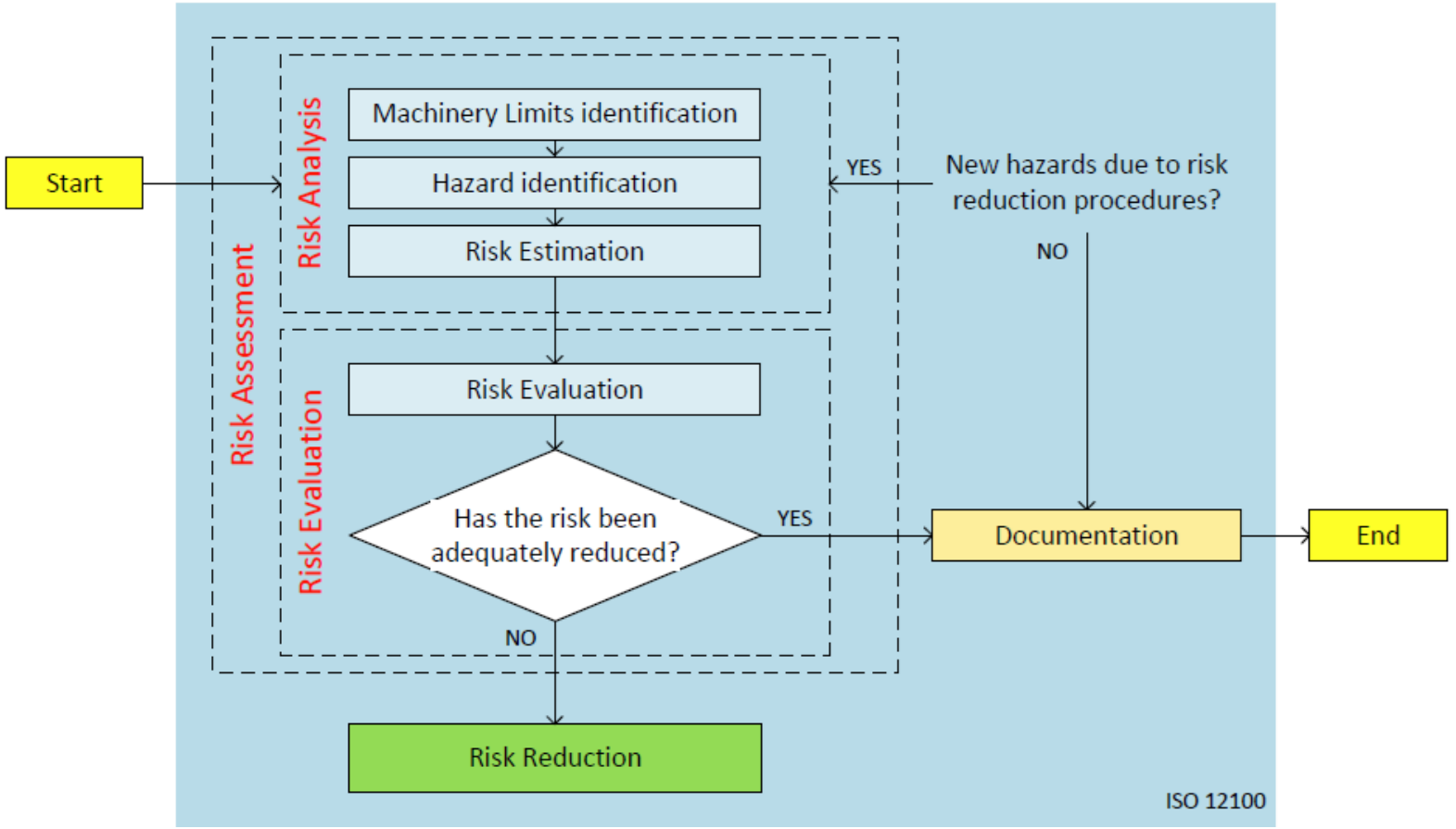
Safety of machinery - … - Risk Assessment

機械安全 - …… - 風險評估

The Risk Assessment is composed by several operations:

風險評估由幾項操作組成：

- **Machinery Limits** identification
  辨別機械限制
- **Hazard** identification 辨別危害
- Risk **Estimation** 風險估計
- Risk **Evaluation** 風險評測



Safety of Machinery + Functional Safety 機械安全+功能安全

Ingenieurbüro Q3

Safety of machinery - … - Risk Reduction

機械安全 - …… - 降低風險

3-step Method and protective measures

implemented by designers: 設計師實施的三步法與保護措施：

1. **Inherently safe design measures** 本質安全的設計措施
2. **Safeguarding and complementary protective measures**

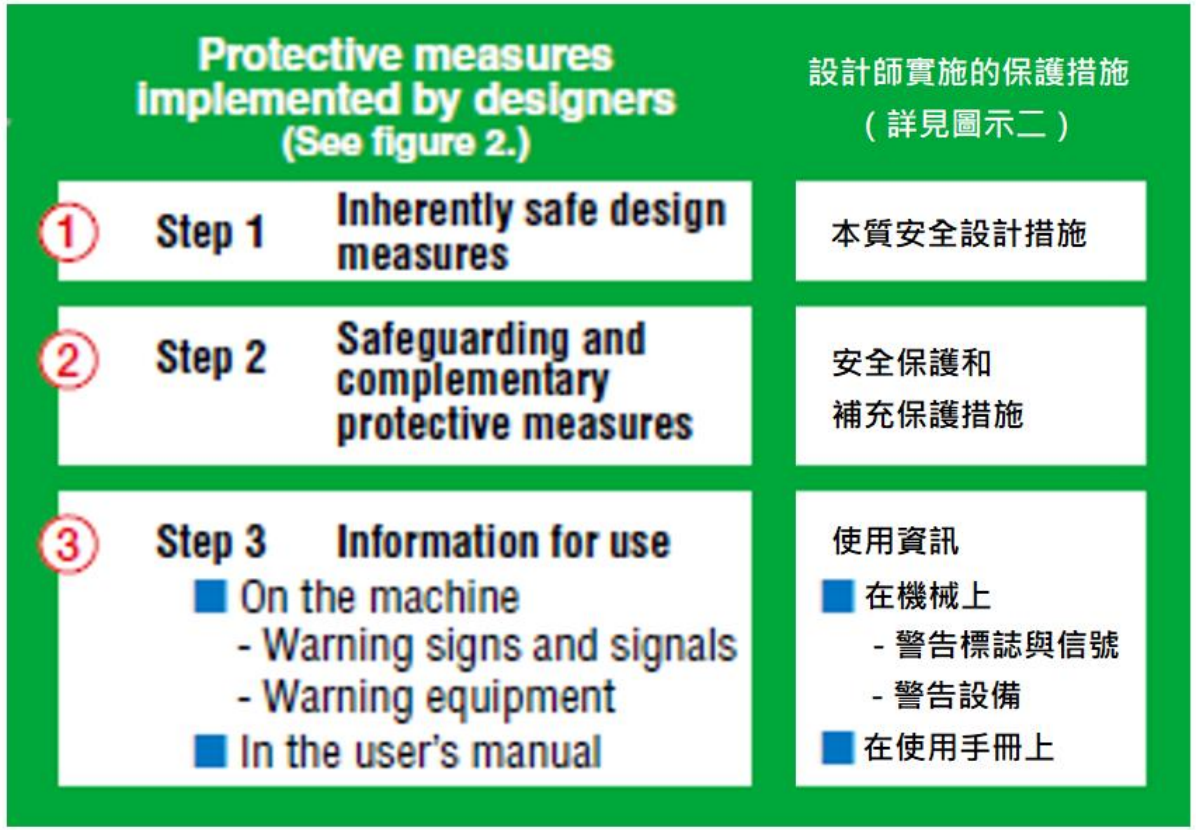
保護和補充保護措施

3. **Information for use** 使用資訊

According to priority,

these measures are ordered as 1, 2, and then 3.

根據優先順序，這些措施按順序排列為1、2和3。



Safety of Machinery + Functional Safety 機械安全+功能安全

Ingenieurbüro Q3

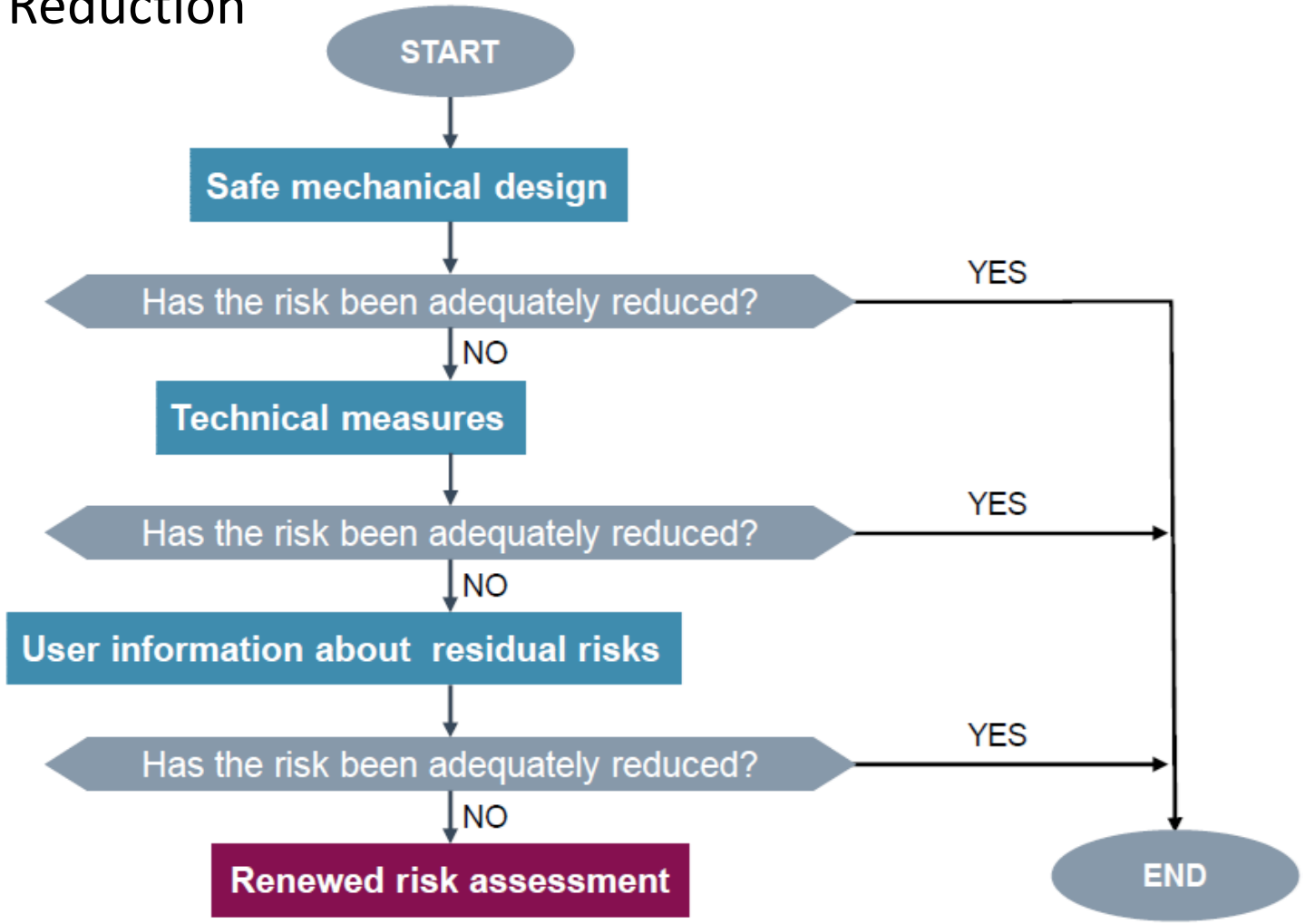
Safety of machinery - … - Risk Reduction

機械安全 - …… - 降低風險

1

2

3



Safety of Machinery + Functional Safety 機械安全+功能安全

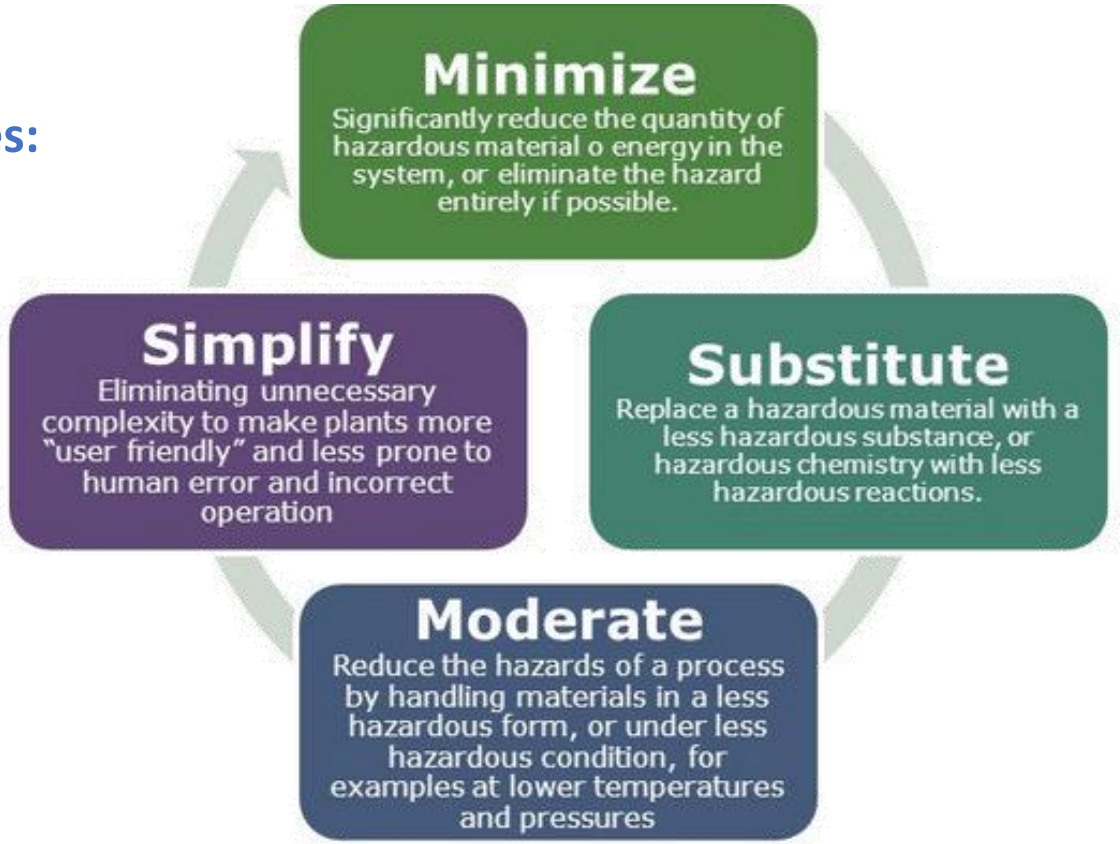
Ingenieurbüro

Safety of machinery - … - Risk Reduction by inherently safe design measures

機械安全 - …… - 通過本質安全的設計措施降低風險

1. **Inherently safe design measures/principles:**

- Minimisation/Elimination
- Simplification
- Substitution
- Moderation



Safety of Machinery + Functional Safety 機械安全+功能安全

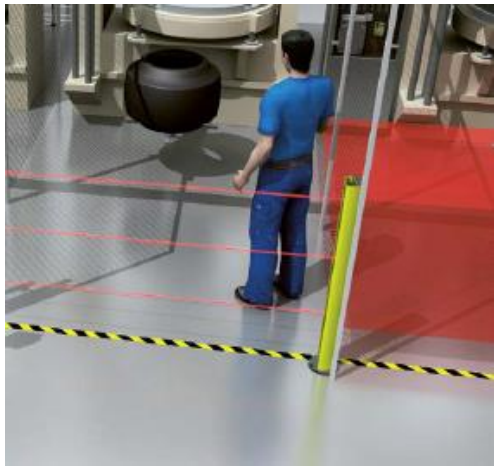
Ingenieurbüro

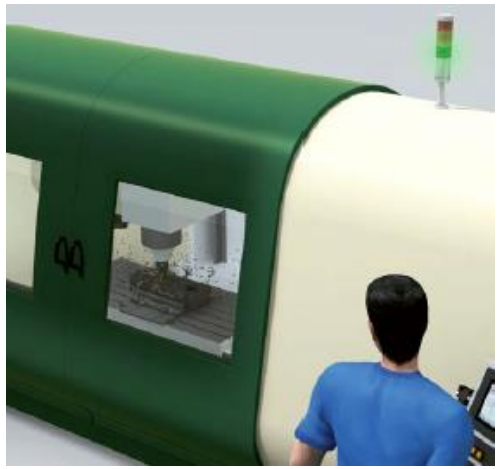
Safety of machinery - … - Risk Reduction by safeguarding + protective measures

機械安全 - …… - 通過防護+保護措施降低風險

2. **Safeguarding and complementary protective measures** 保護和補充保護措施

- Protective devices that are part of a safety function, e.g., covers, doors, light curtains, … 作為安全功能一部分的保護裝置，例如蓋子、門、光幕……
- Monitoring units (monitoring position, speed, etc.) or 監控單元（監控位置，速度等）或
- Measures to reduce emissions 減少排放的措施






Safety of machinery - … - Risk Reduction by information for use

機械安全 - …… - 根據使用資訊減少風險

3. **Information for use**

- Communication means, such as texts, words, signs, signals, symbols, or diagrams, used separately or in combination to provide information to the user (employer and/or affected persons)
- The information shall contain all directions required for safe and intended use of a machine
- To achieve this purpose, it shall also inform and warn the user about residual risk

Safety of Machinery + Functional Safety 機械安全+功能安全

Ingenieurbüro Q3

Safety of machinery - … - Risk Reduction by additional measures (user)

機械安全 - …… - 通過額外措施降低風險（使用者）

- ADDITIONAL DESIGN MEASURES 其他設計措施

Alternative materials, methods, or energy levels shall be substituted to reduce the risk of harm from hazards, where practicable 在可行的情況下，應採用替代材料、方法或能級，以降低危害造成傷害的風險

- ADDITIONAL PROTECTIVE MEASURES 其他保護措施

Additional guards, safeguarding devices, and complementary protective measures shall be provided to reduce risk, where practicable 在可行的情況下，應提供額外的守護、防護裝置與補充保護措施，以降低風險

Safety of Machinery + Functional Safety 機械安全+功能安全

Ingenieurbüro Q3

Safety of machinery - … - Risk Reduction 機械安全 - … - 降低風險

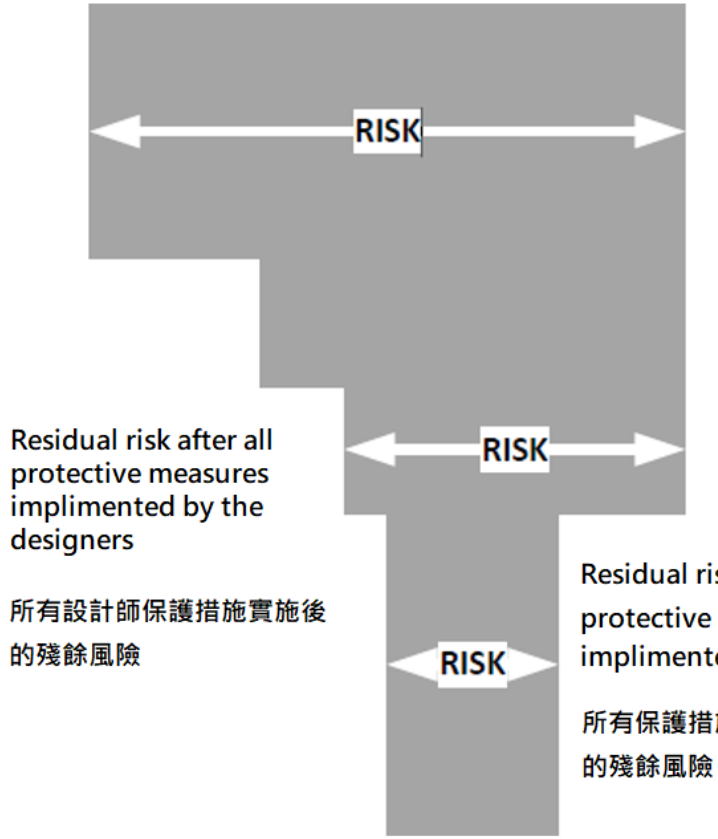
Risk Assessment | Designer 風險評估 | 設計師

設計師實施的保護措施
（詳見圖示二）

① **Step 1** 本質安全設計措施

② **Step 2** 安全保護和
補充保護措施

③ **Step 3** 使用資訊
- 在機械上
  - 警告標誌與信號
  - 警告設備
- 在使用手冊上



Residual risk after all protective measures implimented by the designers

所有設計師保護措施實施後的殘餘風險

Residual risk after all protective measures implimented

所有保護措施實施後的殘餘風險

Risk Assessment | User 風險評估 | 使用者

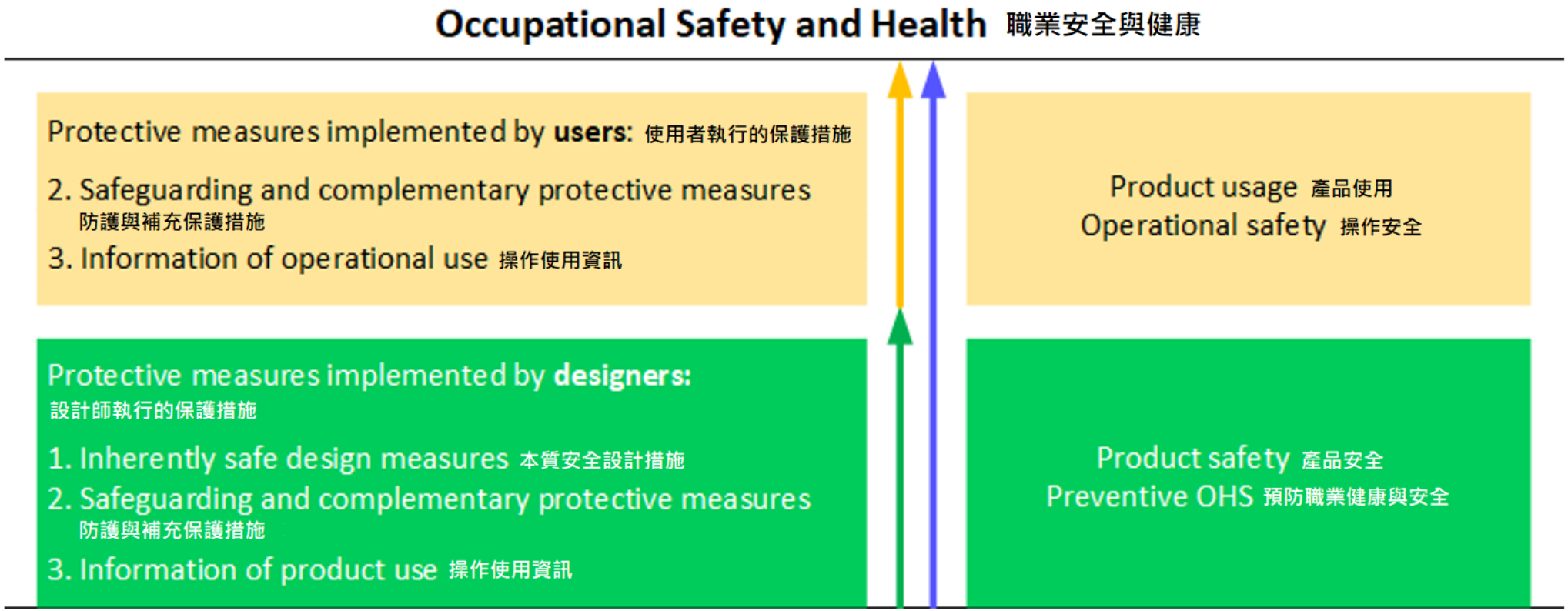
Protective measures implemented by users Including measures based on the **information of use** provided by the designers

使用者實施的保護措施
包括基於設計師提供的使用資訊而實施的措施

Safety of Machinery + Functional Safety 機械安全+功能安全

Ingenieurbüro Q3

Safety of machinery - … - Risk Reduction 機械安全 - … - 降低風險



Safety of Machinery + Functional Safety 機械安全+功能安全

Ingenieurbüro Q3

Functional safety of E/E/PES

《電氣/電子/可程式電子安全相關系統的功能安全》

IEC 61508-1 I fig. 2 I Safety Lifecycle

IEC 61508-1| 圖示二 | 安全生命週期

Safety of Machinery + Functional Safety 機械安全+功能安全

Ingenieurbüro Q3

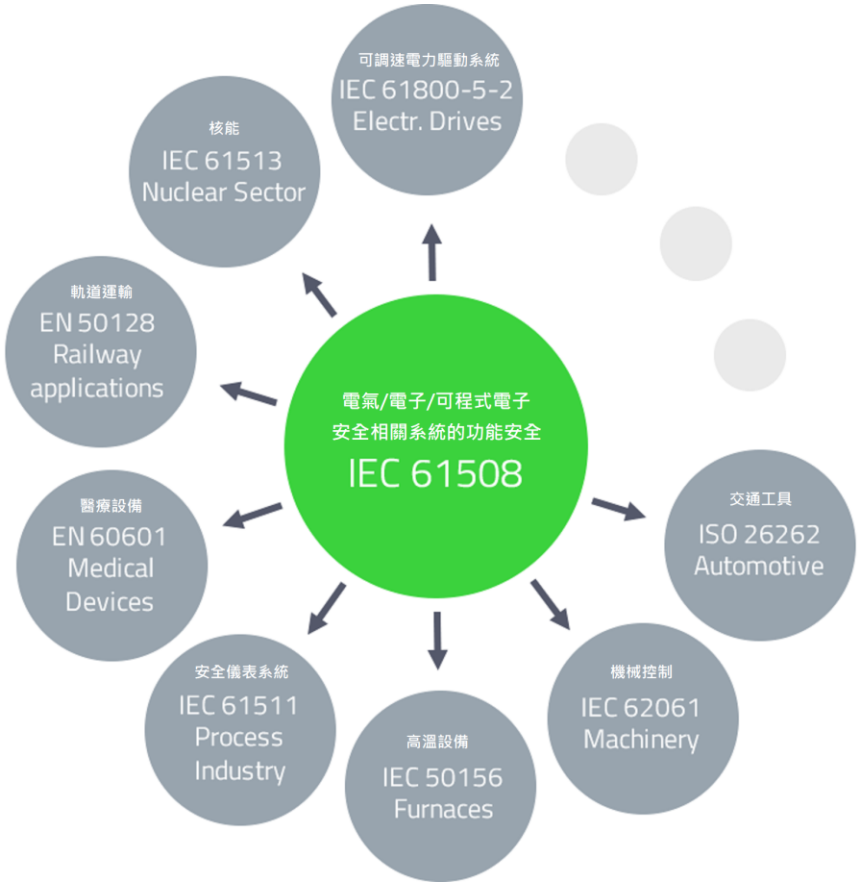
Functional safety of E/E/PES 《電氣/電子/可程式電子安全相關系統的功能安全》

Why evaluate a product/system for functional safety?

為何要評估產品/系統的功能安全性？

- A functional safety assessment determines whether a product meets standards and performance requirements created to protect against potential risks, including injuries and even death 功能安全評估確定產品是否符合為防止潛在風險（包括傷害甚至死亡）而製定的標準和性能要求
- Compliance is driven by customer requirements, legislation, regulations, and insurance demands 合規性由客戶要求，立法、法規和保險要求驅動

Functional Safety, as a term and as an engineering discipline, has emerged with the advancement of complex programmable electronics
功能安全作為一個術語和工程學科，隨著複雜可編程電子學的發展而出現



Safety of Machinery + Functional Safety 機械安全+功能安全

Ingenieurbüro Q3

Functional safety of E/E/PES 《電氣/電子/可程式電子安全相關系統的功能安全》

IEC 61508-4:2010 defines **Functional Safety** as: **IEC 61508-4：2010將功能安全定義為：**

"part of the overall safety relating to the EUC and the EUC control system that depends on the correct functioning of the E/E/PE safety-related systems and other risk reduction measures"

"與EUC和EUC控制系統相關的整體安全的一部分，取決於E / E / PE安全相關係統的正確運行和其他降低風險的措施"

EUC

Equipment under control

受控設備

[theater winch]

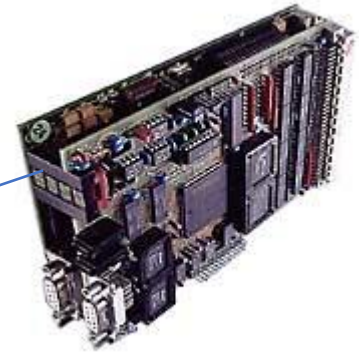
劇院捲揚機

EUC control system

受控設備控制系統

[axle control computer]

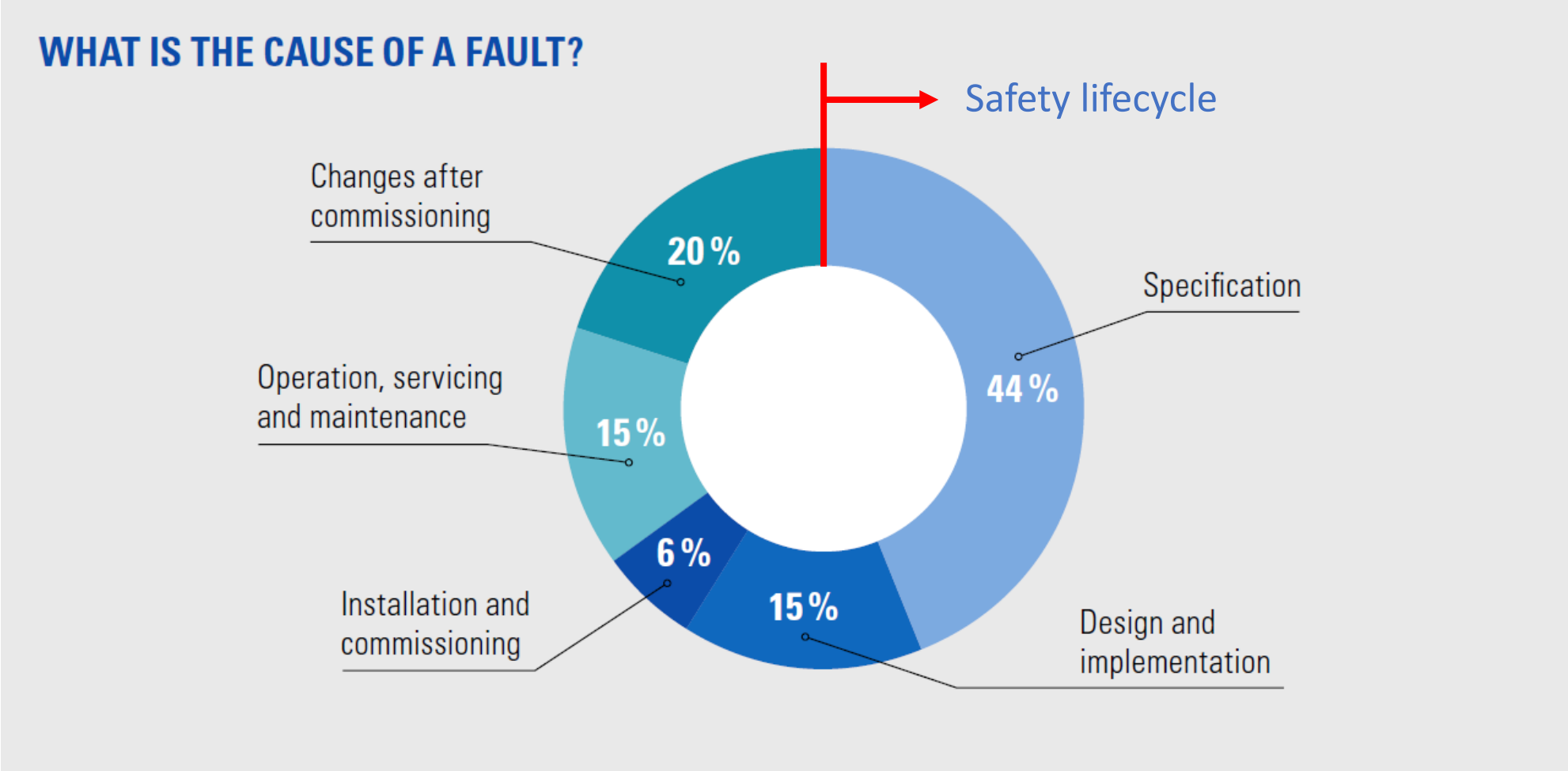
軸控制計算機



The definitions of Functional safety show that it is not related to a specific technology. **功能安全的定義顯示它與特定技術無關。**

Safety of Machinery + Functional Safety

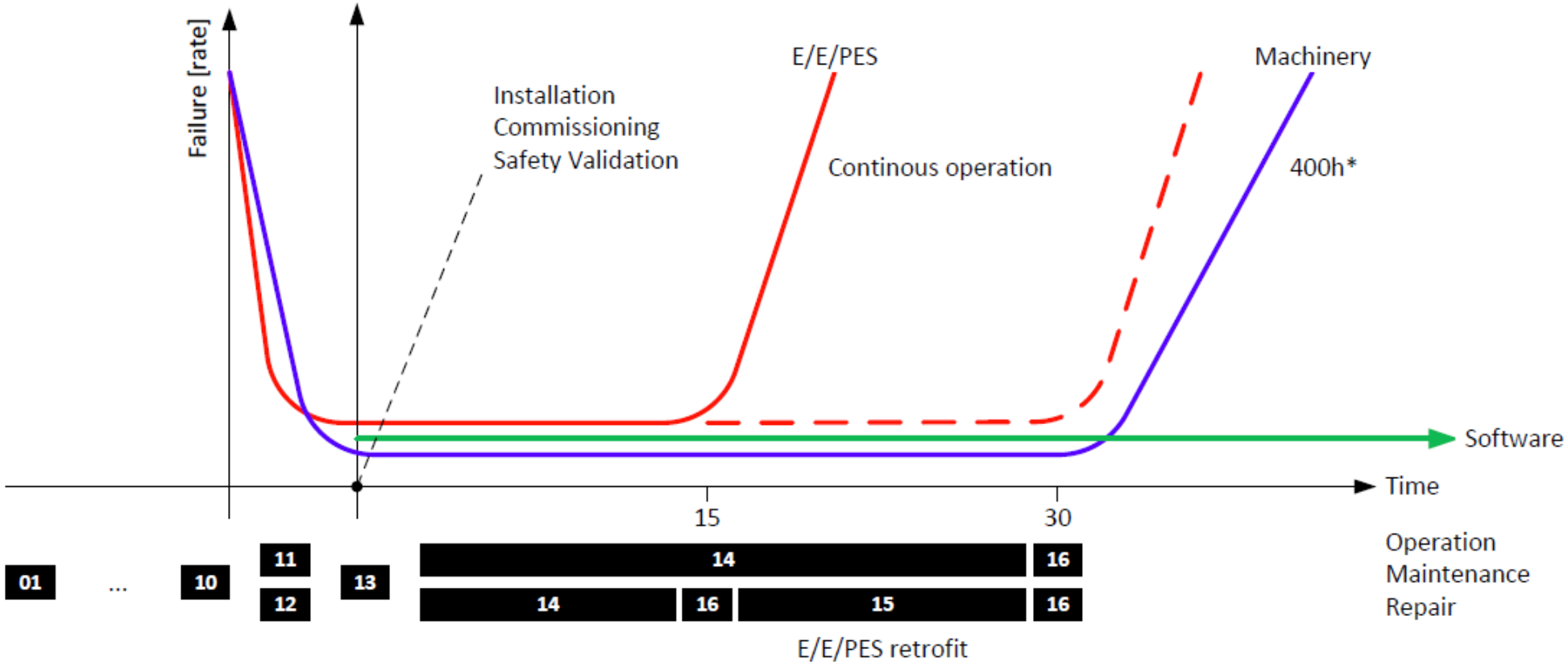
Ingenieurbüro Q3



Safety of Machinery + Functional Safety 機械安全+功能安全

Ingenieurbüro Q3

Functional safety of E/E/PES 《電氣/電子/可程式電子安全相關系統的功能安全》



* FEM 9.511/9.755 (S.W.P): 400h ≙ 30 years operation [2,67 min/d * 330 d/y * 30 y | kmi = 0,8255 (50% full/50% half) | factor 1.1]
FEM 9.511/9.755 (S.W.P): 400h ≙ 20 years operation [3,33 min/d * 330 d/y * 20 y | kmi = 1,000 (100%) | factor 1.1]

Ingenieurbüro Q3

Functional safety of E/E/PES – Hardware (HW) safety integrity

E / E / PES的功能安全 - 硬件（HW）安全完整性

Principles to achieve the intended HW safety integrity (IEC 61508-2): 實現預期硬件安全完整性的原則（IEC 61508-2）：

- **Redundancy** 冗餘

→ Diversity of redundant channels to eliminate common cause failures →冗餘通道的多樣性，以消除共因故障

- **Failure detection** 故障檢測

→ per IEC 61508, detection implies a reaction to a safe (operating) state →根據IEC 61508，檢測意味著對安全（運行）狀態的反應

→ For fail-safe applications, this can mean activation of the fail-safe state →對於故障安全應用程序，這可能意味著激活故障安全狀態

- **Reliability of components** 組件的可靠性

→ Probability of dangerous failure (on demand - PFD, per hour - PFH) in accordance with target failure measure of the required SIL →根據所需SIL的目標故障測量，危險故障的概率（按需要- PFD，每小時 - PFH） PFD=系統無法在需要時執行其設計功能的概率。

Safety of machinery - General principles for design – “Risk graph” (I)

機械安全 - 設計的一般原則 - “風險圖” （I）

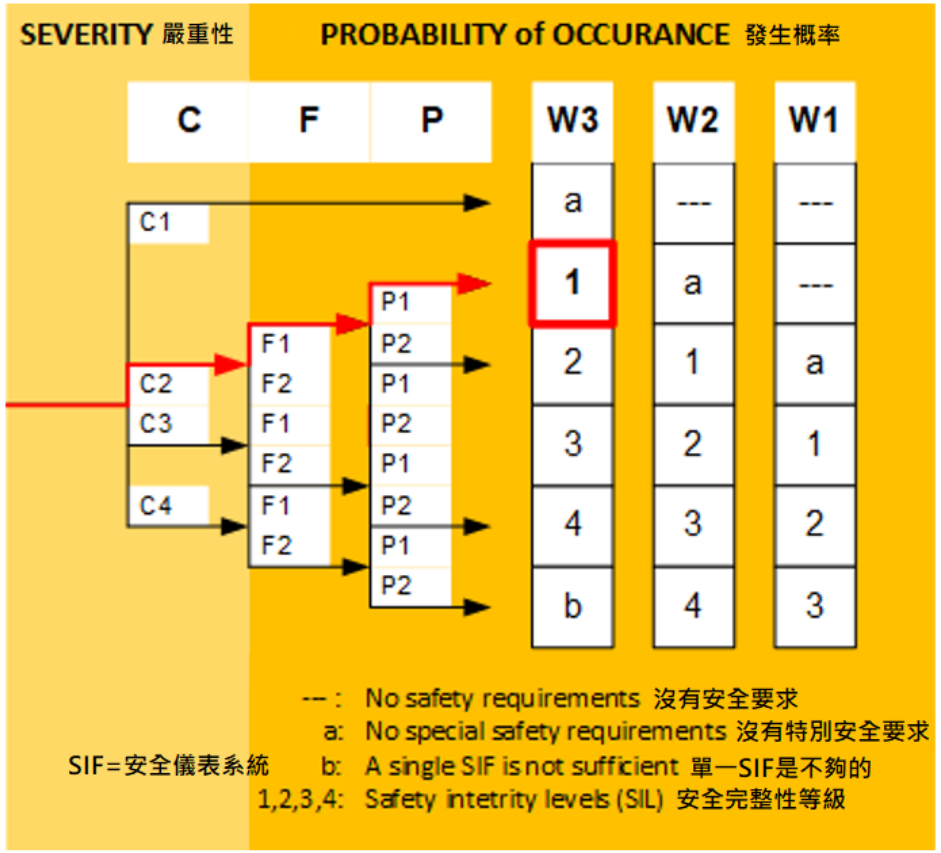
Example: No people on stage / suspended load above stage coming (i.e. falling) down

範例：沒有人在舞台上/懸掛在舞台上面的負載下降（例如掉下）

Risk estimation related to mechanical hazard: 與機械危害相關的風險評估：

- Consequence (C) → C2: Serious 結果（C）→C2：嚴重
- Frequency /exposure time (F) → F1: Rare 頻率/曝光時間（F）→F1：罕見
- Possibility of avoiding (P) → P1: Possible 避免（P）→P1的可能性：可能
- Demand rate [in absence of SIF] (W) → W3: High

  需求率[沒有SIF]（W）→W3：高



Safety of Machinery + Functional Safety 機械安全+功能安全

Ingenieurbüro Q3

Safety of machinery - General principles for design – “Risk graph” (II)

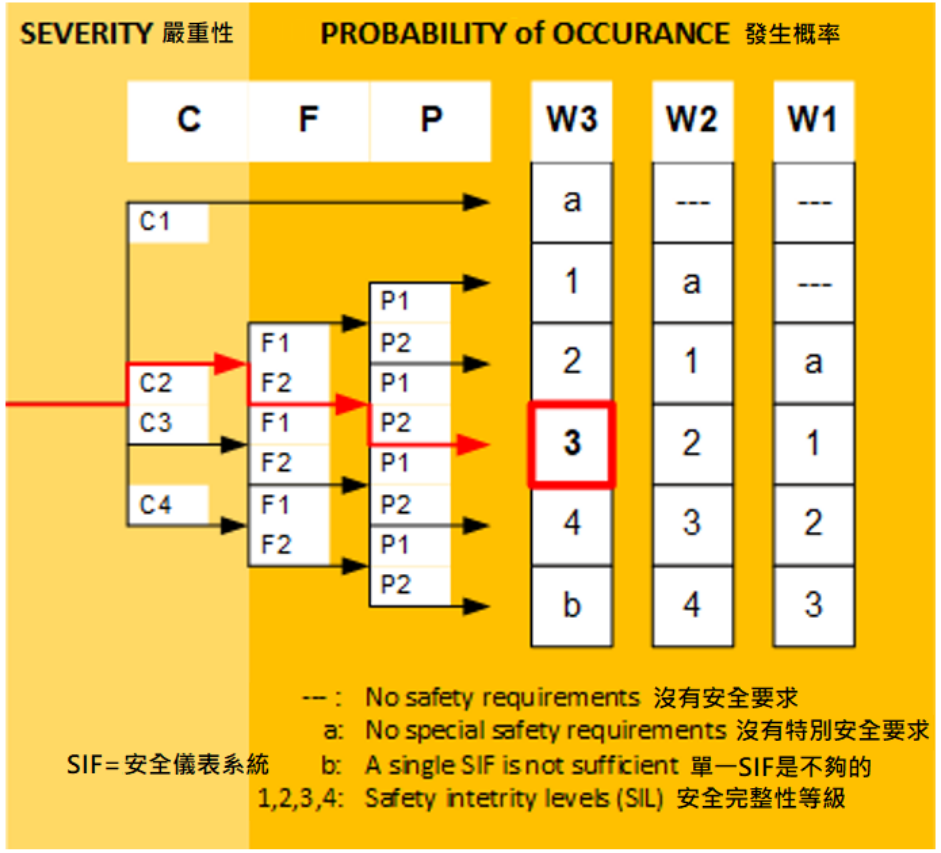
機械安全 - 設計的一般原則 - “風險圖” （II）

Example: People on stage / suspended load above stage coming (i.e. falling) down

範例：人在舞台上/懸掛在舞台上面的負載下降（例如掉下）

Risk estimation related to mechanical hazard: 與機械危害相關的風險評估：

- Consequence (C) → C2: Serious 結果（C）→C2：嚴重
- Frequency /exposure time (F) → F2: Frequent
  頻率/曝光時間（F）→F2：頻繁
- Possibility of avoiding (P) → P2: Almost impossible
  避免（P）→P2的可能性：幾乎不可能
- Demand rate [in absence of SIF] (W) → W3: High
  需求率[沒有SIF]（W）→W3：高



Safety of Machinery + Functional Safety 機械安全+功能安全

Ingenieurbüro Q3

Functional safety of E/E/PES

《電氣/電子/可程式電子安全相關系統的功能安全》

λ_S – Failure rate of safe failures

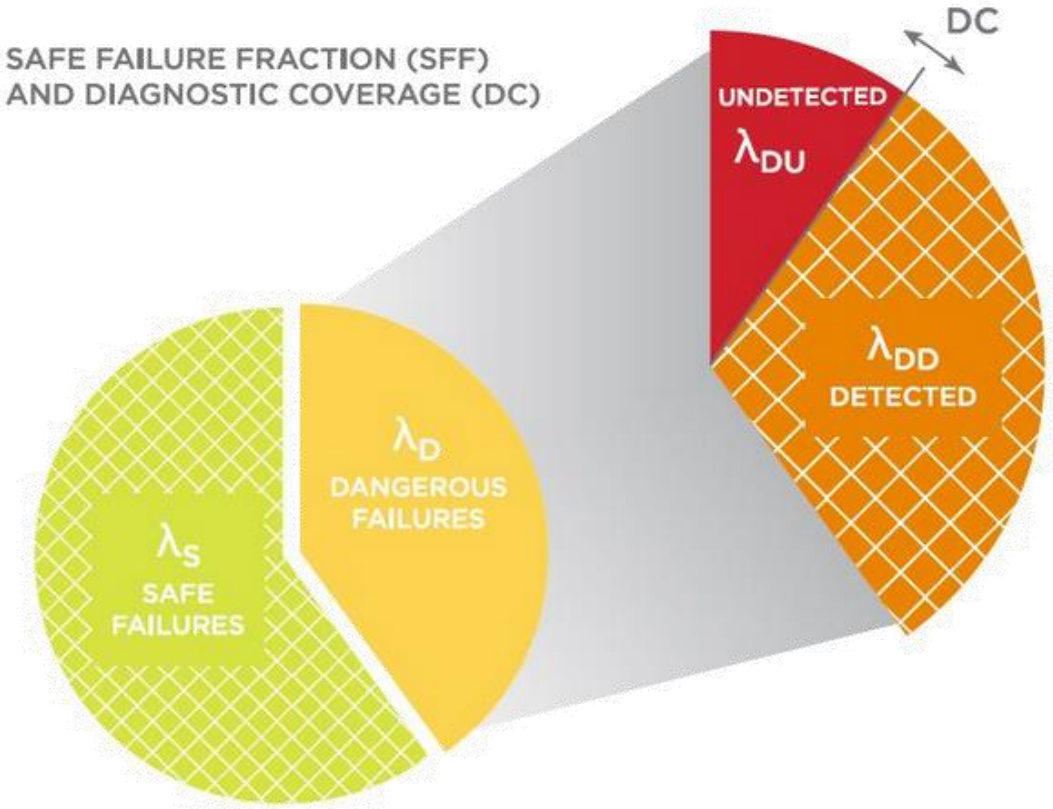
- λ_{SD} – … safe detected …
- λ_{SU} – … safe undetected …

λ_D – Failure rate of dangerous failures

- λ_{DD} – … dangerous detected …
- λ_{DU} – … dangerous undetected …

SFF – Safe Failure Fraction

DC – Diagnostic Coverage



$$SFF = \frac{\lambda_S + \lambda_{DD}}{\lambda_S + \lambda_D}$$

$$DC = \frac{\lambda_{DD}}{\lambda_{DD} + \lambda_{DU}}$$

Safety of Machinery + Functional Safety 機械安全+功能安全

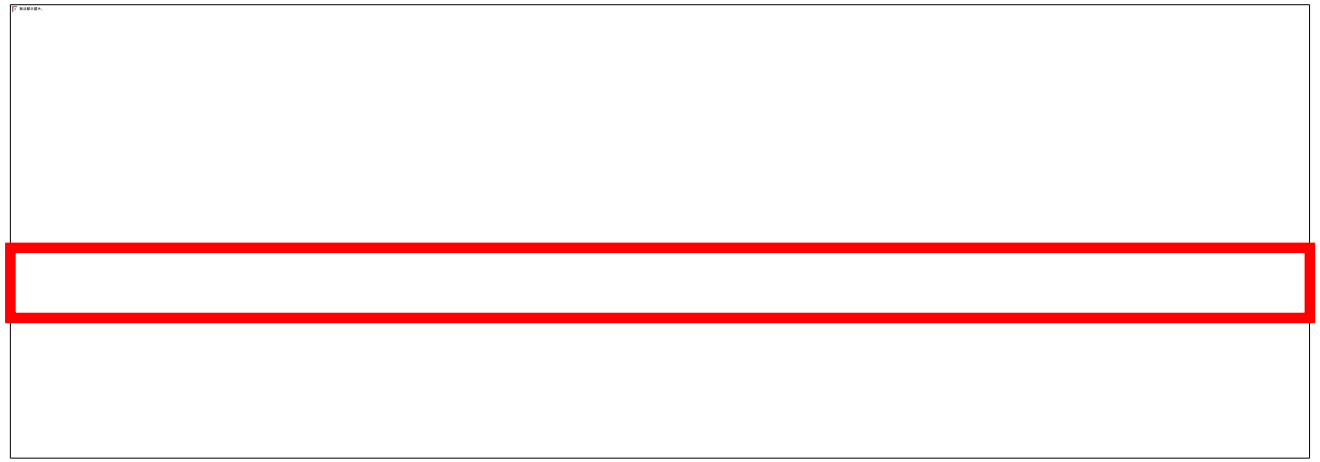
Ingenieurbüro

Functional safety of E/E/PES

《電氣/電子/可程式電子安全相關系統的功能安全》

Low demand

Reaction time 反應時間 0,1 ...1s



High demand

Reaction time 反應時間 5...150ms

1 year = 8760 hours ≈ 10^4 hours

Safety of Machinery + Functional Safety 機械安全+功能安全

Ingenieurbüro Q3

Functional safety of E/E/PES – SIL 3 system E / E / PES 功能安全 - SIL 3系統

„SIL3 system“ SIL3系統

=

E/E/PES with SIL3-SIFs

帶有SIL3-SIF的E / E / PES

電氣/電子/可程式電子安全相關系統的功能安全

[Safety-related E/E/PE-system
with a complete set of
safety instrumented functions (SIF)
with safety integration level (SIL) 3]

[安全相關的E / E / PE系統有一套完整的
安全儀表功能（SIF）
安全完整性等級（SIL）3]

Safety instrumented functions (SIF) with SIL3: 帶有SIL3的安全儀表功能

„Deadman“ Release "使役開關"釋放 SS1 + SS2	Safe torque off + operating stop 安全的扭矩關閉 + 運行停止 STO + SOS	Safe CAM Safe safety switch 安全的限位開關 安全的安全開關 SCA	Safely-limited speed + acc. 安全限制速度 +準確度 SLS + SLA	Safely-limited torque 安全限制的扭矩 SLT
Safe torque range 安全扭矩範圍 STR	Safely-limited position 安全限制位置 SLP	Safe brake control/ monitor 安全煞車控制監視 SBC + SBM	Safe group synchronisation 安全群組同步 „SGS“	E-stop* 緊急停止 stop category 0 stop category 1

Safety-related E/E/PES 電氣 / 電子 / 可程式電子安全相關系統

* Not SIF but supplementary safety function! *不是安全儀表功能，但是有輔助安全功能！

Safety of Machinery + Functional Safety 機械安全+功能安全

Ingenieurbüro 3Q

Agenda 2|4 議程2|4

Entertainment technology 娛樂技術

Machinery installations - Part 1: **Safety requirements and inspections**

機械設備第1部分：**安全要求和檢查**

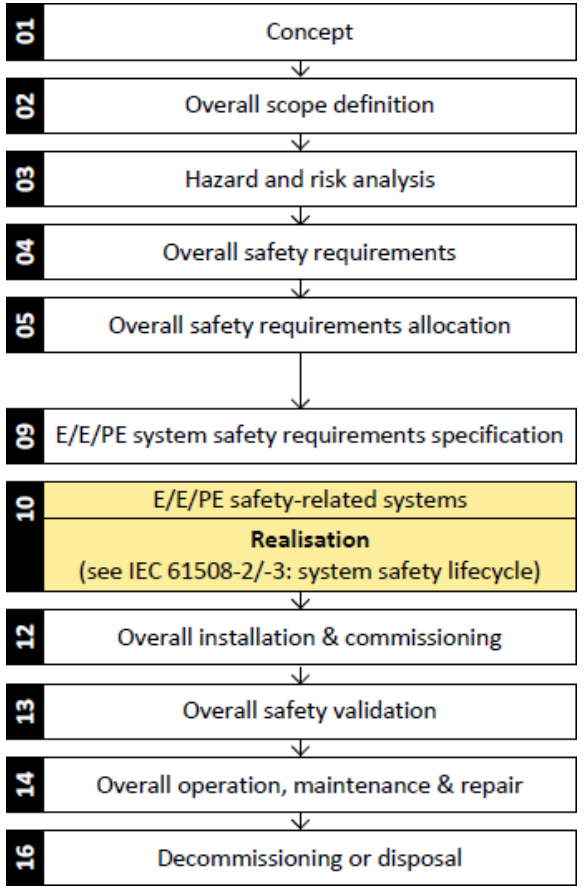
→ DIN 56950-1:2012

Entertainment technology 娛樂技術

Lifting and load-bearing equipment for stages and other production areas within the entertainment Industry 用於娛樂業內舞台與其他製作區域的起重與承重設備

Specifications for general requirements 一般要求的規定

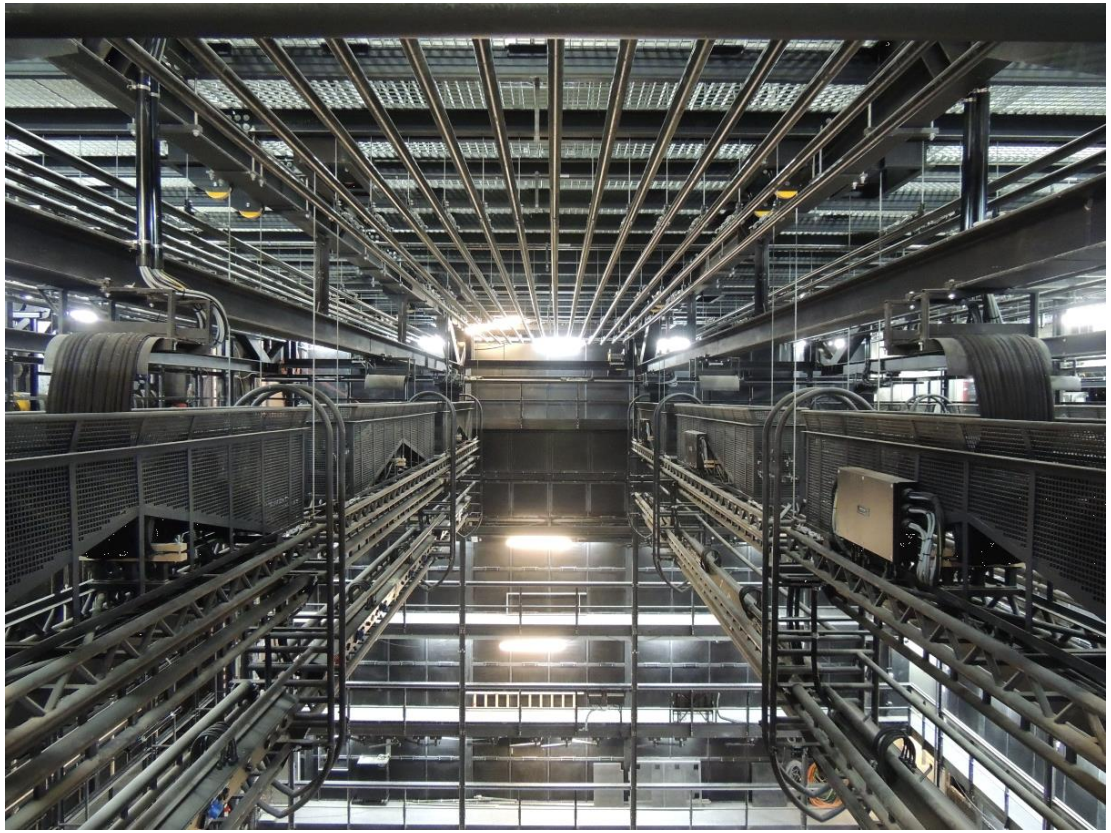
→ prEN 17206:2018



Safety of Machinery + Functional Safety 機械安全+功能安全

Ingenieurbüro Q3

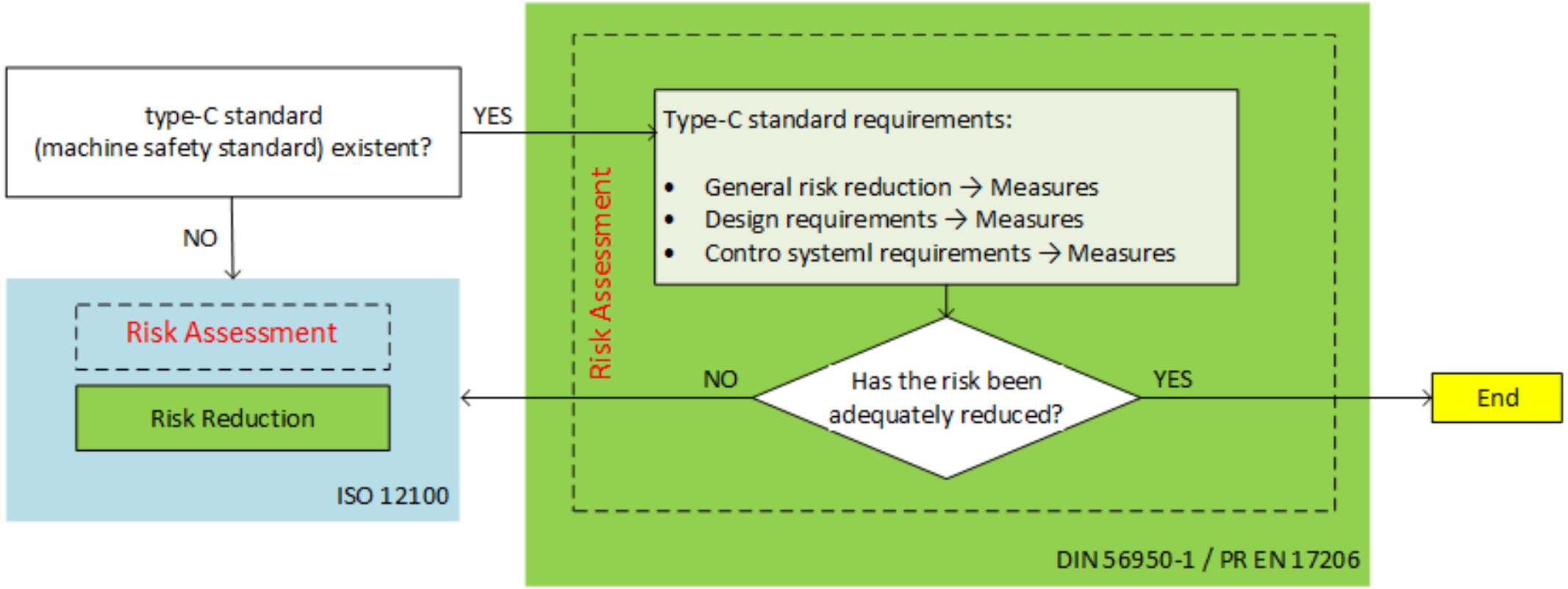
Entertainment technology – Impressions 娛樂技術 - 印象



Ingenieurbüro Q3

Entertainment technology – Risk Assessment + Reduction

娛樂技術 - 風險評估+降低



Safety of Machinery + Functional Safety 機械安全+功能安全

Ingenieurbüro Q3

Entertainment technology – Risk Reduction

DIN 56950-1: Section 5 & 6: Inherently safe design measures

- Design of structural elements 結構元件設計 :

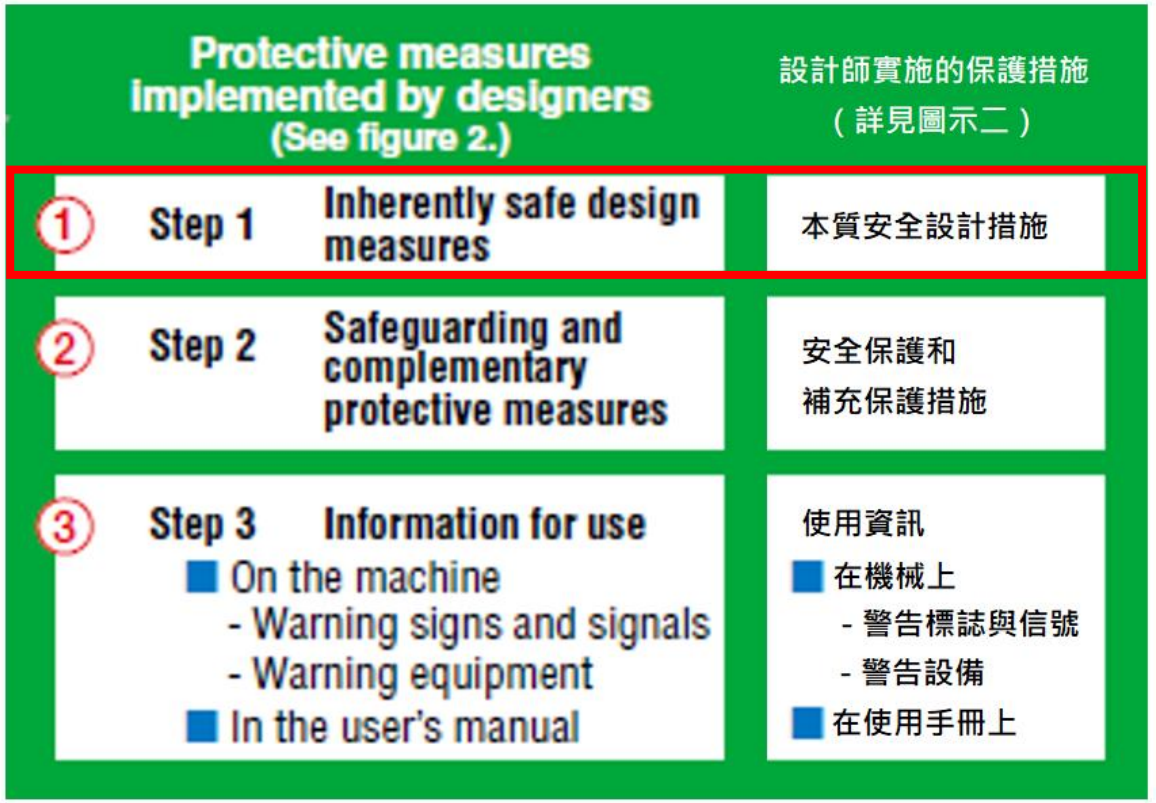
  max (2 x $F_{nominal}$ | 1 x $F_{failure}$)

- → gear box, shafts, …→齒輪箱、傳動軸……
- Doubling working coefficient (safety factor 10)
  加倍工作係數（安全係數10）

→ wire ropes, chains, shakles →鋼絲繩、鏈條、卸扣

- Additional requirements 其他要求

→ diameter drum/pulleys, rope termination, avoidance crushing/shearing/trapping, ...



Safety of Machinery + Functional Safety 機械安全+功能安全

Ingenieurbüro Q3

Entertainment technology – Risk Reduction

DIN 56950-1: Section 7: Technical measures

- General requirements

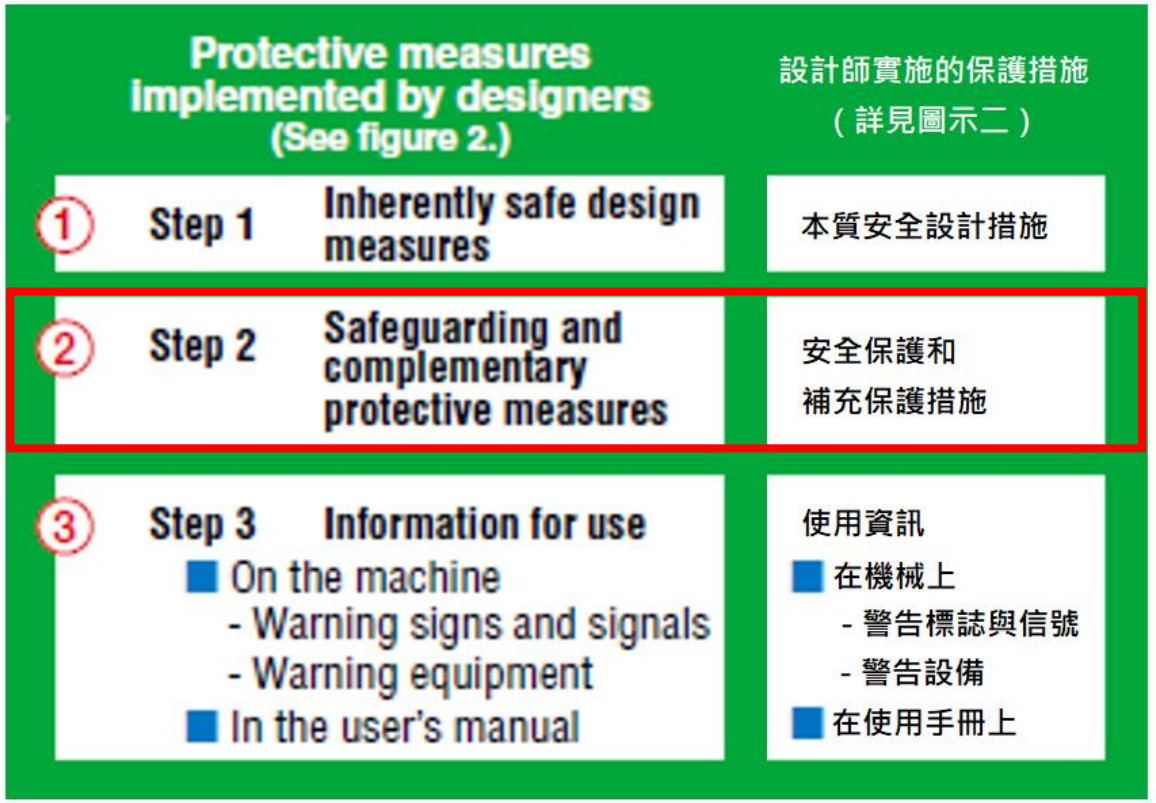
→ Selection of components, power supply, EMC, …

- Protection of equipment

→ Overcurrent, power failure, temperature, lightning, …

- „SIL3 system“ = E/E/PES with SIL3-SIFs

→ Safety-related E/E/PE-system with a complete set of safety instrumented functions (SIF) with safety integration level (SIL) 3



Safety of Machinery + Functional Safety 機械安全+功能安全

Ingenieurbüro Q3

Entertainment technology – Risk Reduction

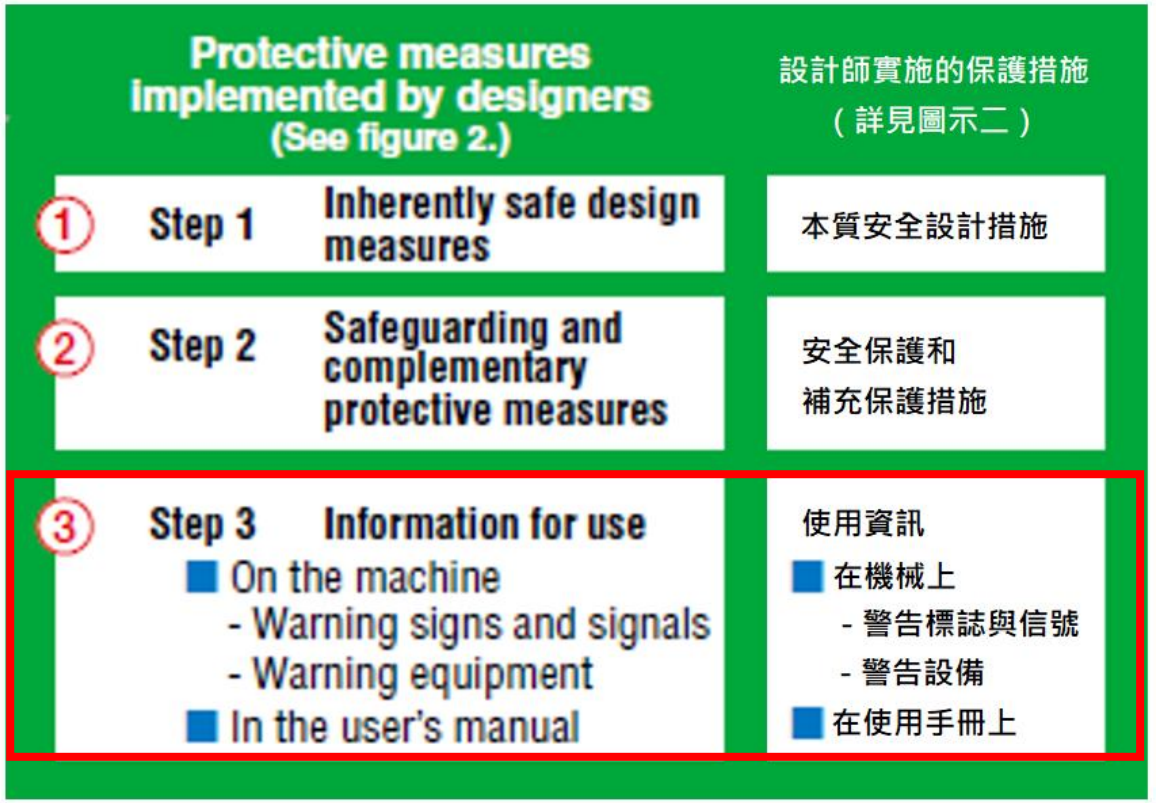
DIN 56950-1: Section 8: Information for use

- Technical data
- Marking
- Operation/User‘s manual + Maintenance Manuals

→ Machinery

→ Computer control system

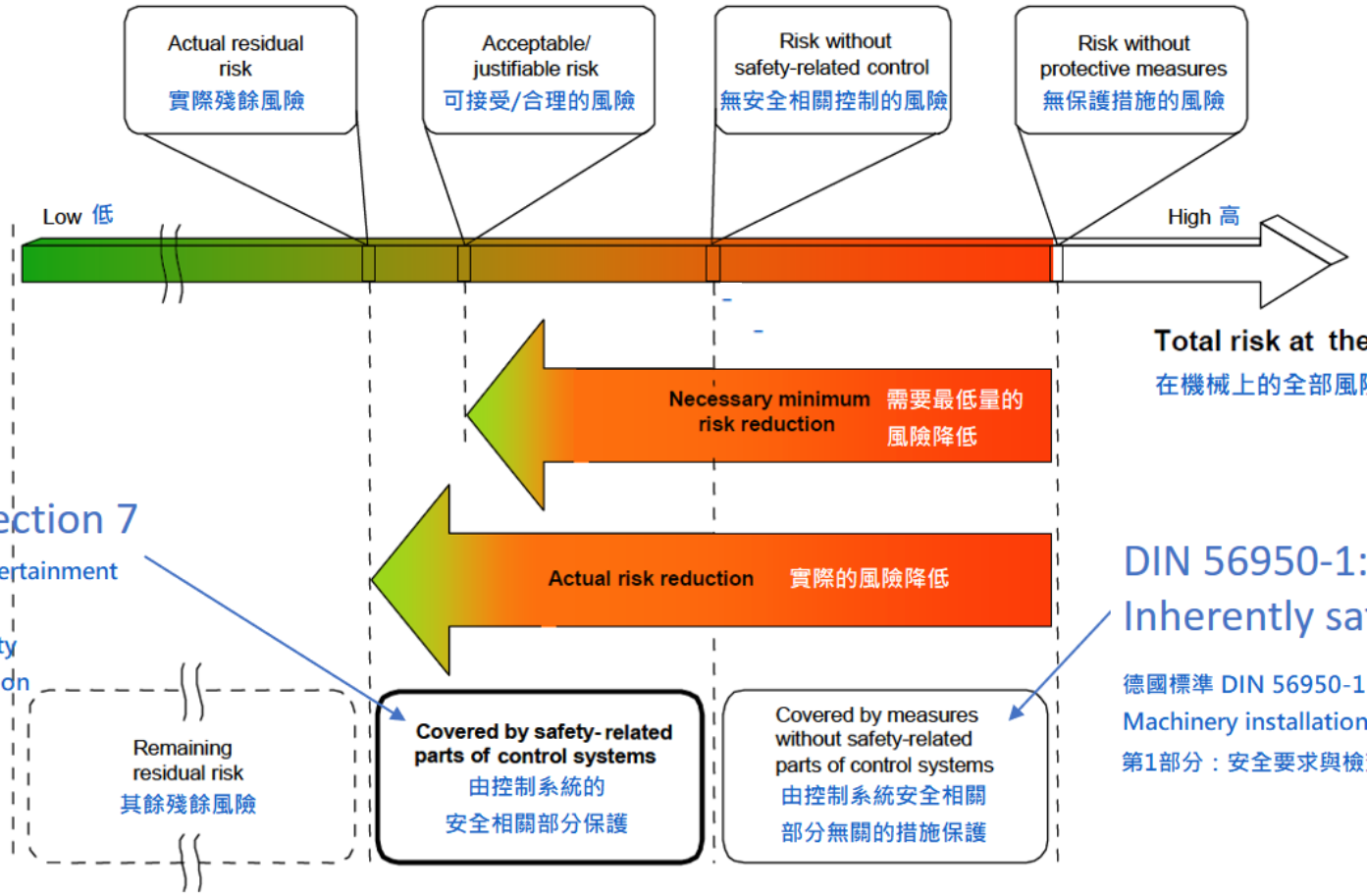
- System log book



Safety of Machinery + Functional Safety 機械安全+功能安全

Ingenieurbüro Q3

Functional safety of E/E/PES 《電氣/電子/可程式電子安全相關系統的功能安全》



IEC 61508
DIN 56950-1: Section 7
德國標準 DIN 56950-1 Entertainment technology - Machinery installations - Part 1: Safety requirements and inspection
娛樂技術 - 機械安裝 - 第1部分：安全要求與檢查：第7段

DIN 56950-1: Section 5 & 6
Inherently safe design measures
德國標準 DIN 56950-1 : Entertainment technology - Machinery installations 娛樂技術 - 機械安裝 - 第1部分：安全要求與檢查：第5與第6段 - 本質安全的設計措施

Safety of Machinery + Functional Safety 機械安全+功能安全

Ingenieurbüro Q3

Agenda 3|4 議程3|4

Entertainment technology 娛樂技術

Machinery installations - Part 1: **Safety requirements and inspections**

機械設備第1部分：安全要求與檢查

→ DIN 56950-1:2012

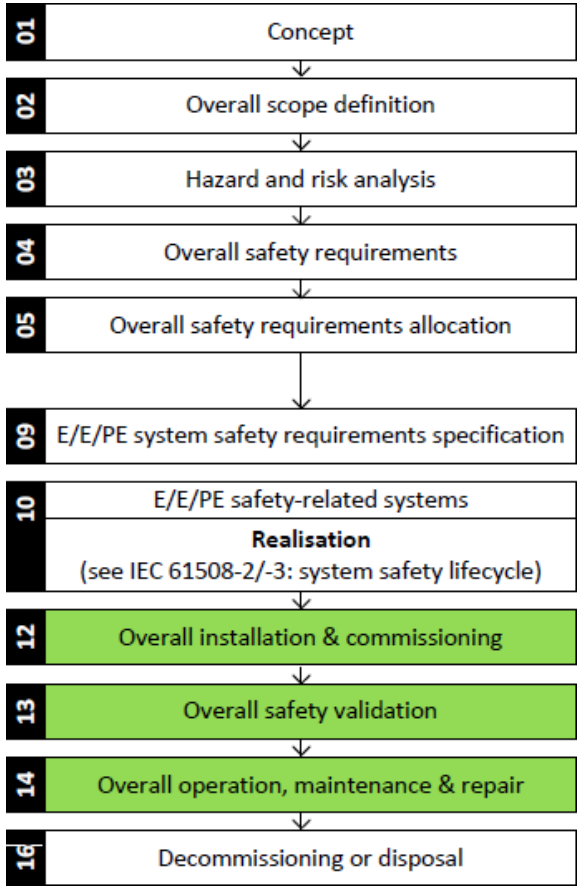
Entertainment technology 娛樂技術

Lifting and load-bearing equipment for stages and other production areas

within the entertainment Industry 娛樂產業用於舞台與其他製作的起重和承重設備

Specifications for general requirements 一般要求的規格

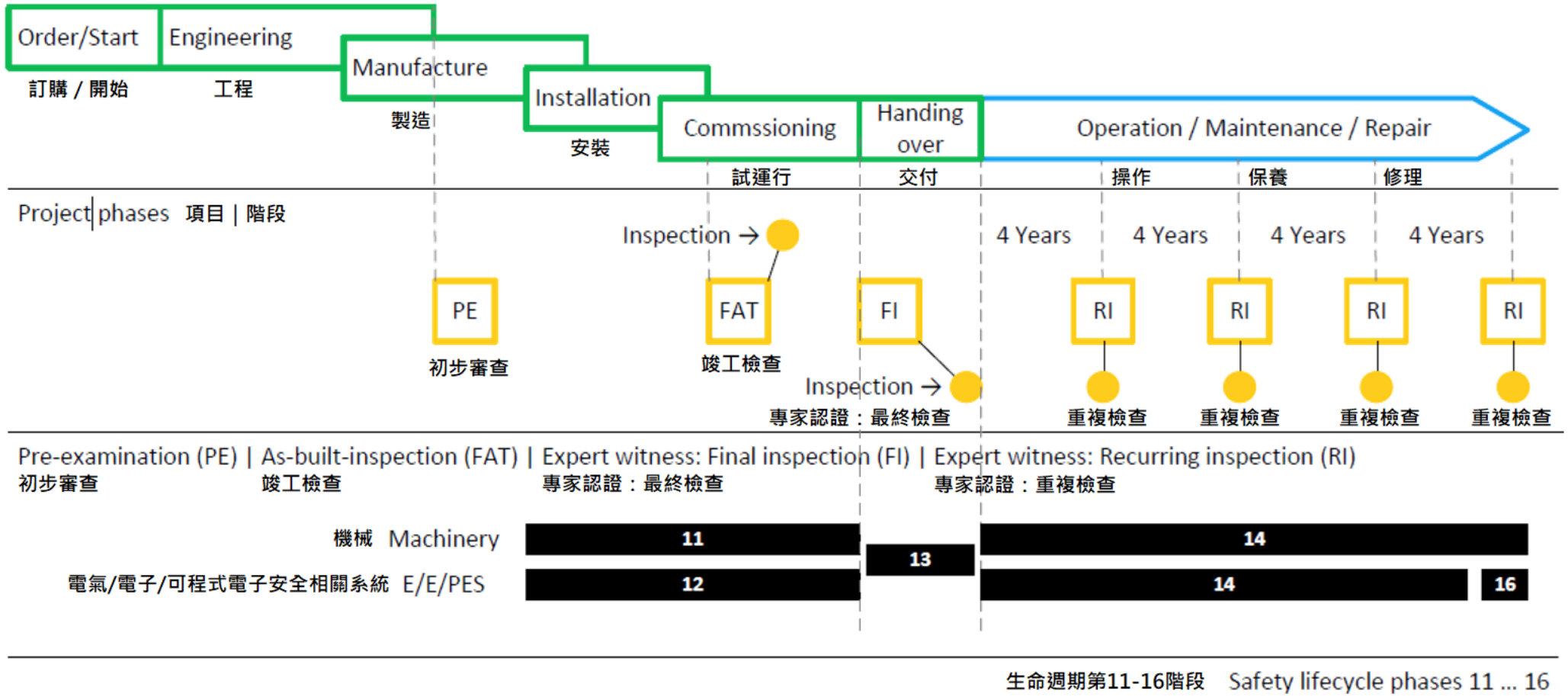
→ prEN 17206:2018



Safety of Machinery + Functional Safety 機械安全+功能安全

Ingenieurbüro Q3

System validation | Operation | Maintenance 系統驗證| 操作| 保養



Safety of Machinery + Functional Safety 機械安全+功能安全

Ingenieurbüro Q3

System validation | Operation | Maintenance 系統驗證| 操作| 保養

What? 什麼	When? 何時	Who? 誰	Reference 參考
Expert witness: Final inspection 專家證明：最終檢驗	After installation + commissioning 安裝+調試後	Safety Expert 安全專家	…
Recurring inspection 經常性檢查 Extraordinary inspection 例外性檢查	Every 4 years of operation 每4年運作一次 In case of changes, add-ons, …如有更改、增加，.....	Safety Expert 安全專家	…
System maintenance 系統維護	Once/twice a year 一年一次/兩次	User: Qualified persons 使用者：合格人員 Erection company 安裝公司	Maintenance Contract 維護合約
Visual inspection 目視檢查 Functional inspection 功能檢查	Daily/weekly/monthly 每日/每週/每月	User: Qualified persons 使用者：合格人員	Maintenance Manual 維護手冊
Troubleshooting training 問題排除培訓 System/Safety training 系統/安全培訓	Once/twice a year 一年一次/兩次	Erection company 安裝公司 Safety Expert 安全專家	…

Safety of Machinery + Functional Safety 機械安全+功能安全

Ingenieurbüro Q³

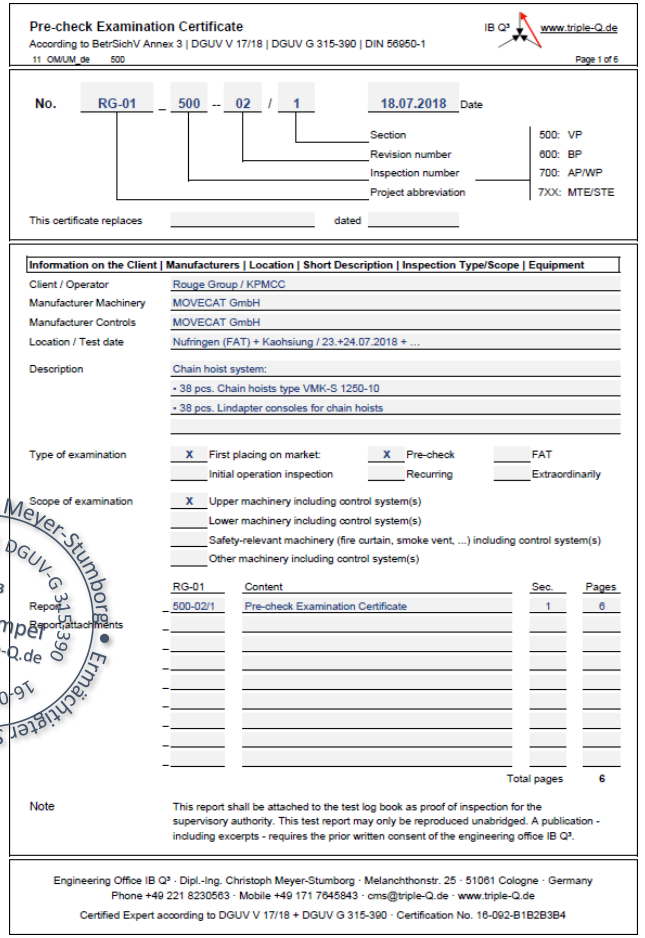
System validation | Operation | Maintenance 系統驗證| 操作| 保養

Preliminary examination (PE) | Evaluation of technical documentation:

初步審查（PE）| 評估技術文件：

- Specification with SIF description 帶SIF（安全儀表系統）描述的規範
- Hazard and risk analysis 危害和風險分析
- Design / manufacturing documents 設計/製造文件
- Design Checks 設計檢查
- Electrical diagrams + program flowcharts 電氣圖表+程序流程圖
- Certificates (SIL3, DIN EN 1090-2 / -3, ...) 證書（SIL3，DIN EN 1090-2 / -3，……）

→ PE documentation 初步審查（PE）|文檔



Pre-check Examination Certificate

According to BetrSichV Annex 3 | DGUV V 17/18 | DGUV G 315-390 | DIN 56950-1

IB Q³ www.triple-Q.de

11_OM/UM_de 500 Page 1 of 6

No. RG-01 _ 500 -- 02 / 1 18.07.2018 Date

Section
Revision number
Inspection number
Project abbreviation

500: VP
600: BP
700: AP/WP
7XX: MTE/STE

This certificate replaces _____ dated _____

Information on the Client | Manufacturers | Location | Short Description | Inspection Type/Scope | Equipment	
Client / Operator	Rouge Group / KPMCC
Manufacturer Machinery	MOVECAT GmbH
Manufacturer Controls	MOVECAT GmbH
Location / Test date	Nufringen (FAT) + Kaohsiung / 23.+24.07.2018 + ...
Description	Chain hoist system: • 38 pcs. Chain hoists type VMK-S 1250-10 • 38 pcs. Lindapter consoles for chain hoists

Type of examination: X First placing on market: X Pre-check ___ FAT; ___ Initial operation inspection ___ Recurring ___ Extraordinarily

Scope of examination:
X Upper machinery including control system(s)
___ Lower machinery including control system(s)
___ Safety-relevant machinery (fire curtain, smoke vent, ...) including control system(s)
___ Other machinery including control system(s)

	RG-01	Content	Sec.	Pages
Report	500-02/1	Pre-check Examination Certificate	1	6
Report attachments				

Total pages 6

Note: This report shall be attached to the test log book as proof of inspection for the supervisory authority. This test report may only be reproduced unabridged. A publication - including excerpts - requires the prior written consent of the engineering office IB Q³.

Dipl.-Ing. Christoph Meyer-Stumborg · Sachverständiger · Ermächtigter · DGUV-V 17/18 | DGUV-G 315-390 · Q³ Prüfstempel · www.triple-Q.de · 16-092 B1B2B3B4

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Certified Expert according to DGUV V 17/18 + DGUV G 315-390 · Certification No. 16-092-B1B2B3B4

Safety of Machinery + Functional Safety 機械安全+功能安全

Ingenieurbüro Q³

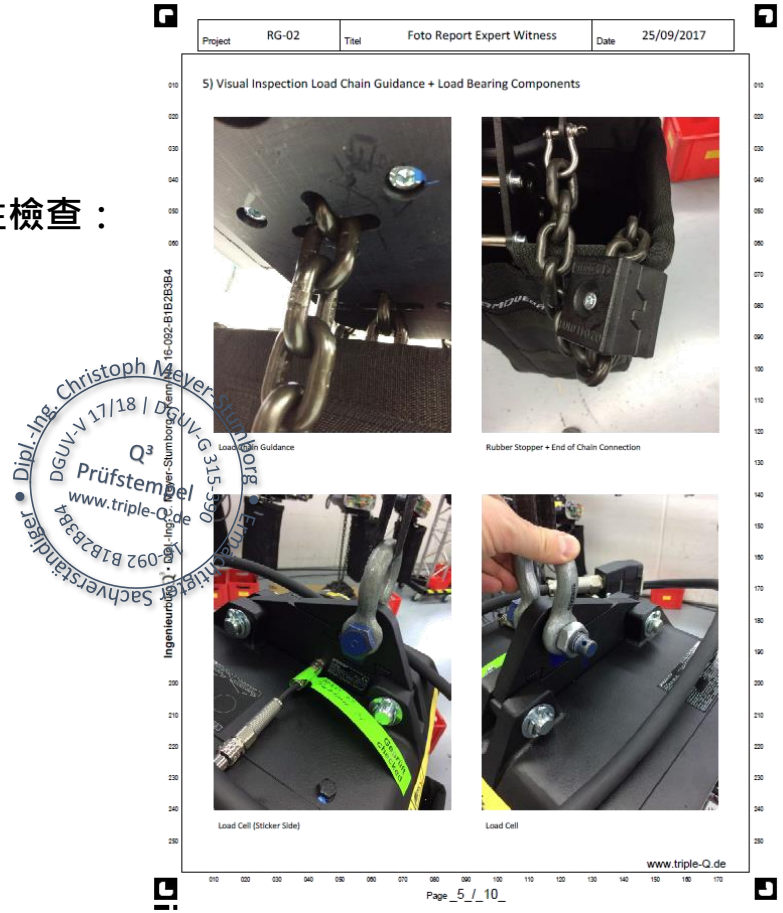
System validation | Operation | Maintenance 系統驗證| 操作| 保養

As-built inspection (FAT) | Conformity check of technical equipment

with technical documentation: 竣工檢查（FAT）| 技術設備與技術文檔的符合性檢查：

- Construction design 施工設計
- Load bearing capacity 承載能力
- Technical equipment 技術設備
- User Information 使用者資訊

→ FAT documentation FAT=Factory Acceptance Test 工廠驗收測試文檔



Safety of Machinery + Functional Safety 機械安全+功能安全

Ingenieurbüro Q³

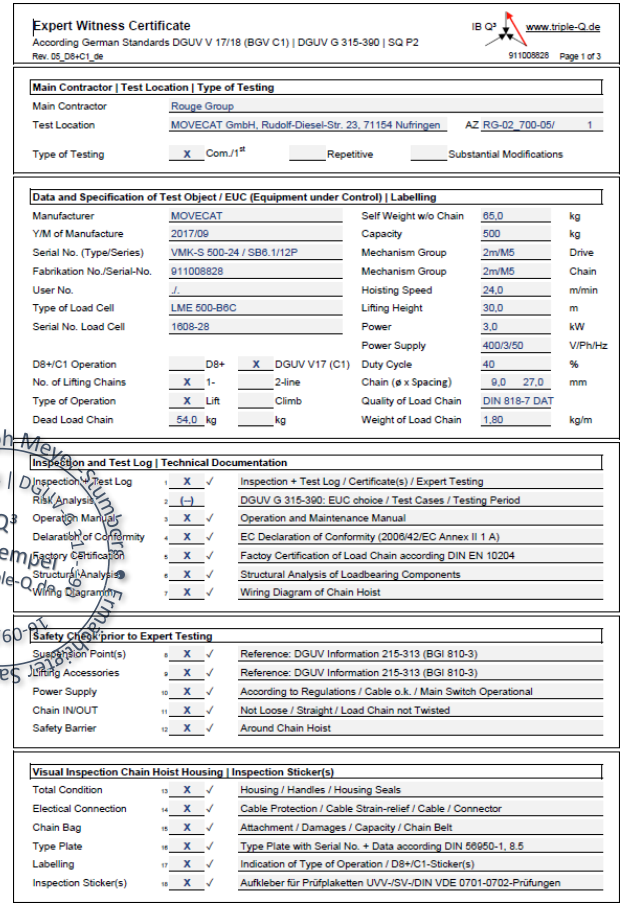
System validation | Operation | Maintenance 系統驗證| 操作| 保養

Expert witness: Final inspection (FI) | Testing of the operational systems:

專家證明：最終檢查（FI）| 測試操作系統：

- Completeness of technical equipmente **工業技術設備的完整性**
- Proper installation + labelling **正確安裝 + 標籤**
- Function test safety devices + safety instrumented functions **功能測試安全裝置 + 安全儀表功能**
- Load capacity + brake test (test loads) **負載能力+制動測試（測試負載）**
- Check test criteria manufacturer **檢查製造商測試標準**
- Installation and operating instructions **安裝和操作說明**

→ Test report + test certificate →測試報告+測試證書



Expert Witness Certificate
According German Standards DGUV V 17/18 (BGV C1) | DGUV G 315-390 | SQ P2
Rev. 05_D8+C1_de
IB Q³ www.triple-Q.de
911008828 Page 1 of 3

Main Contractor | Test Location | Type of Testing

Main Contractor	Rouge Group		
Test Location	MOVECAT GmbH, Rudolf-Diesel-Str. 23, 71154 Nufringen	AZ	RG-02_700-05/ 1
Type of Testing	X Com./1st	Repetitive	Substantial Modifications

Data and Specification of Test Object / EUC (Equipment under Control) | Labelling

Manufacturer	MOVECAT	Self Weight w/o Chain	65,0	kg
Y/M of Manufacture	2017/09	Capacity	500	kg
Serial No. (Type/Series)	VMK-S 500-24 / SB8.1/12P	Mechanism Group	2m/M5	Drive
Fabrikation No./Serial-No.	911008828	Mechanism Group	2m/M5	Chain
User No.	./.	Hoisting Speed	24,0	m/min
Type of Load Cell	LME 500-B6C	Lifting Height	30,0	m
Serial No. Load Cell	1608-28	Power	3,0	kW
		Power Supply	400/3/50	V/Ph/Hz
D8+/C1 Operation	D8+ X DGUV V17 (C1)	Duty Cycle	40	%
No. of Lifting Chains	X 1- 2-line	Chain (ø x Spacing)	9,0 27,0	mm
Type of Operation	X Lift Climb	Quality of Load Chain	DIN 818-7 DAT	
Dead Load Chain	54,0 kg kg	Weight of Load Chain	1,80	kg/m

Inspection and Test Log | Technical Documentation

Inspection + Test Log	1 X ✓	Inspection + Test Log / Certificate(s) / Expert Testing	
Risk Analysis	2 (–)	DGUV G 315-390: EUC choice / Test Cases / Testing Period	
Operation Manual	3 X ✓	Operation and Maintenance Manual	
Delaration of Conformity	4 X ✓	EC Declaration of Conformity (2006/42/EC Annex II 1 A)	
Factory Certification	5 X ✓	Factoy Certification of Load Chain according DIN EN 10204	
Structural Analysis	6 X ✓	Structural Analysis of Loadbearing Components	
Wiring Diagram	7 X ✓	Wiring Diagram of Chain Hoist	

Safety Check prior to Expert Testing

Suspension Point(s)	8 X ✓	Reference: DGUV Information 215-313 (BGI 810-3)	
Lifting Accessories	9 X ✓	Reference: DGUV Information 215-313 (BGI 810-3)	
Power Supply	10 X ✓	According to Regulations / Cable o.k. / Main Switch Operational	
Chain IN/OUT	11 X ✓	Not Loose / Straight / Load Chain not Twisted	
Safety Barrier	12 X ✓	Around Chain Hoist	

Visual Inspection Chain Hoist Housing | Inspection Sticker(s)

Total Condition	13 X ✓	Housing / Handles / Housing Seals	
Electical Connection	14 X ✓	Cable Protection / Cable Strain-relief / Cable / Connector	
Chain Bag	15 X ✓	Attachment / Damages / Capacity / Chain Belt	
Type Plate	16 X ✓	Type Plate with Serial No. + Data according DIN 56950-1, 8.5	
Labelling	17 X ✓	Indication of Type of Operation / D8+/C1-Sticker(s)	
Inspection Sticker(s)	18 X ✓	Aufkleber für Prüfplaketten UVV-/SV-/DIN VDE 0701-0702-Prüfungen	

Safety of Machinery + Functional Safety 機械安全+功能安全

Ingenieurbüro Q3

System validation | Operation | Maintenance 系統驗證| 操作| 保養

The safety of any work equipment used must be

reactively, periodically, proactively + predictively maintained:

所使用的任何工作設備的安全必須是反應性的、定期的、主動 + 可預測的維護：

- Inspections* can detect any damage in good time 檢查*可以及時發現任何損壞
- Action can be decided on and taken 可以決定並採取行動
- Factors causing the damage can be identified and assessed 可以識別與評估造成損害的因素

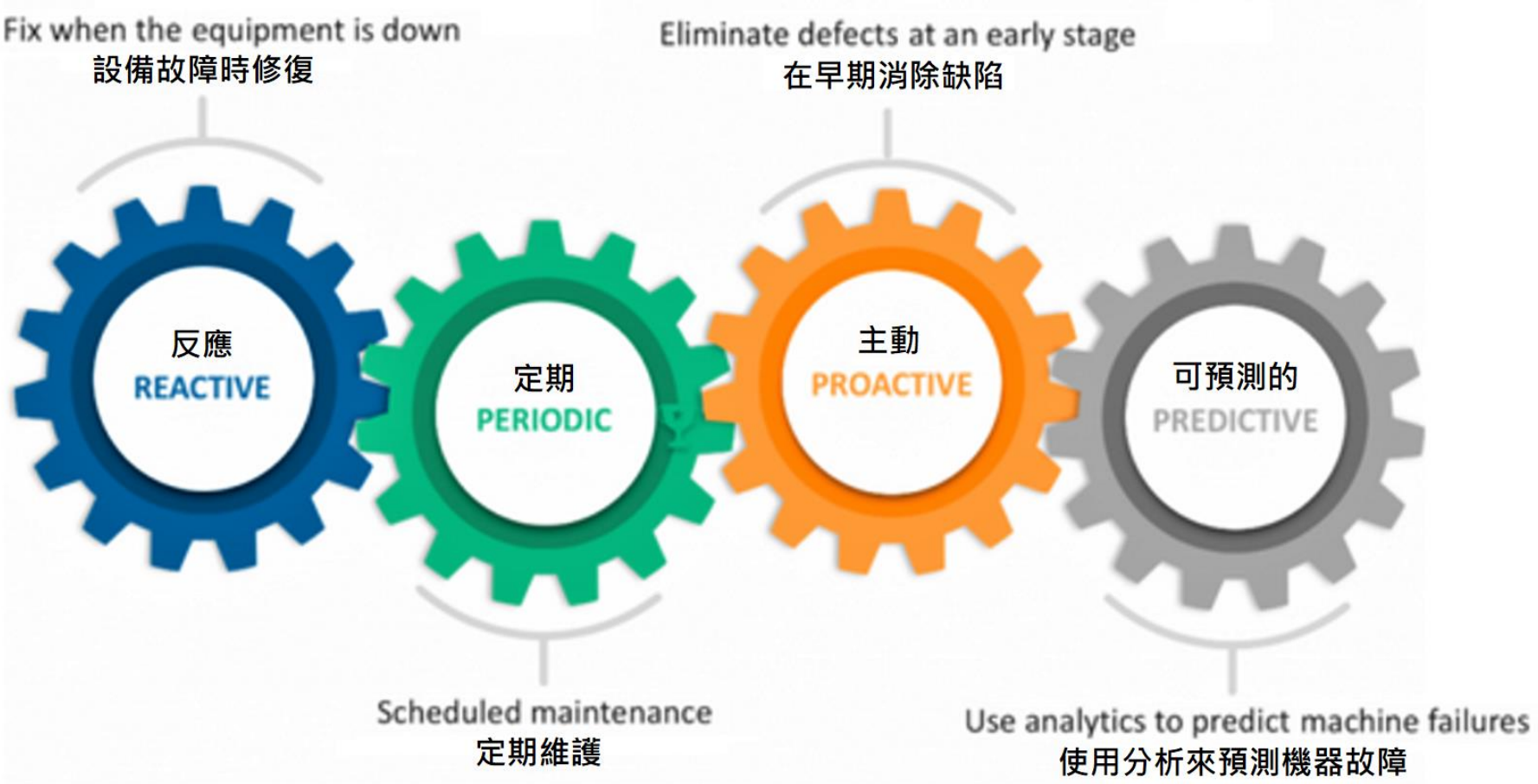
* visible damage and wear, proper functioning, safeness for use, legibility of markings, …

*明顯的損壞和磨損、正常運行、使用安全、標記易讀性……

Safety of Machinery + Functional Safety 機械安全+功能安全

Ingenieurbüro Q3

System validation | Operation | Maintenance 系統驗證| 操作| 保養



Safety of Machinery + Functional Safety 機械安全+功能安全

Ingenieurbüro Q3

System validation | Operation | Maintenance 系統驗證| 操作| 保養

Operation/maintenance: Practices and training requirements for safety-related E/E/PES: 運行/維護：與安全相關的E / E / PES 電氣/電子/可程式電子安全相關系統的實踐與培訓要求：

- Proof testing → integration test list with pass/fail criteria → safety expert 測試證明→帶有通過/失敗標準的整合測試列表→安全專家
- Inspection → separate requirements to inspect SIF for signs of degradation 檢查→單獨要求檢查SIF是否有退化跡象
- Repair → approved and tested by competent authority → safety expert 維修→由主管當局核可與測試→安全專家
- Modification → appropriate change control procedures → safety expert 修改→適當的變更控制程序→安全專家
- Security → SIF should be secured from unauthorised interference 安全性→應保護SIF（安全儀表系統）免受未經授權的干擾
- Performance monitoring → SIF failure reporting + investigation 性能監控→SIF故障報告+調查

Safety of Machinery + Functional Safety 機械安全+功能安全

Ingenieurbüro Q³

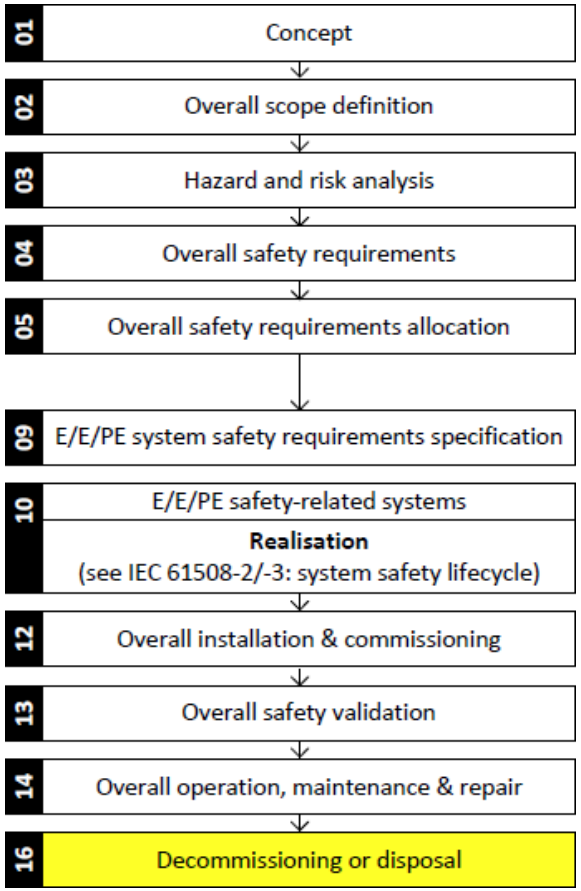
Agenda 4|4 議程 4|4

Benefits from third party inspection and services: 第三方檢查和服務的好處：

a) System is designed to safety standards as IEC 61508, DIN 56950, …:
系統被設計為符合 IEC 61508，DIN 56950等安全標準：
- Detection of damage and wear 檢測損壞和磨損
- Proof testing with full test report → Safeness for use
完整測試報告的證明測試→使用安全

b) System needs refurbishment: 系統需要翻新：
- Full report about system status 有關系統狀態的完整報告
- Starting point for specifying → refurbishment 定義起點→翻新

Training: Safety of machinery + functional safety | OHS/HSE
培訓：機械安全+功能安全|OHS/ HSE



Best practise – Safeties (I) 最佳實踐 - 安全（I）

- Wire rope Ø 3 … 10mm
- Rope termination: press sleeve + eyelet
- Quick link
- Marking (max. mass / wire rope Ø)

Rope diameter for rope type 6 x 19 M with a rated strength of 1770 N/mm² [mm]	Quick-link diameter as specified in DIN 56927 [mm] 	Maximum mass that can be secured with safety rope in the event of falls from a height of 20 cm max.	
		Length 0.6 m [kg]	Length 1.0 m or longer [kg]
3	4	5	9
4	4	10	16
5	5	15	25
6	6	22	36
8	8	40	64
10	10	62	100

Safety of Machinery + Functional Safety 機械安全+功能安全

Ingenieurbüro Q3

Best practise – Safeties (II) 最佳實踐 - 安全（II）

- Attachment at the securing eye on the luminaire and around load-attachment point on the building structure 在燈具上的固定孔處以及建築物結構上的負載連接點附近

→ weakest component determines the load-bearing capacity!

→最薄弱的部件決定了承重能力！

- Safety elements (or “safeties”) must be attached in such a way that there is no drop → 20 cm max! 必須安裝安全元件（或“安全裝置”），使其不會下降→最大20公分！
- Forces 20 cm dropping distance: 20公分下降距離的力量：

→ 78 times of falling mass for a rope length of 0.6 m →鋼索長度為0.6米時，質量下降78倍

→ 48 times of falling mass for a rope length of 1.0 m →鋼索長度為1米時，質量下降48倍

- Best practice: Safety ropes with a shock absorber 最佳實踐：帶減震器的安全鋼索

Safety of Machinery + Functional Safety 機械安全+功能安全

Ingenieurbüro

Best practise – Heavy loads (I) 最佳實務 - 重載 (I)

Rigid structure of load with 4 pick-ups: 帶有4個傳感器的剛性負載結構：

→ statically indefinite 靜態不確定

→ 0,5 x payload per lifting equipment

→每台起重設備的有效載荷為0.5 x

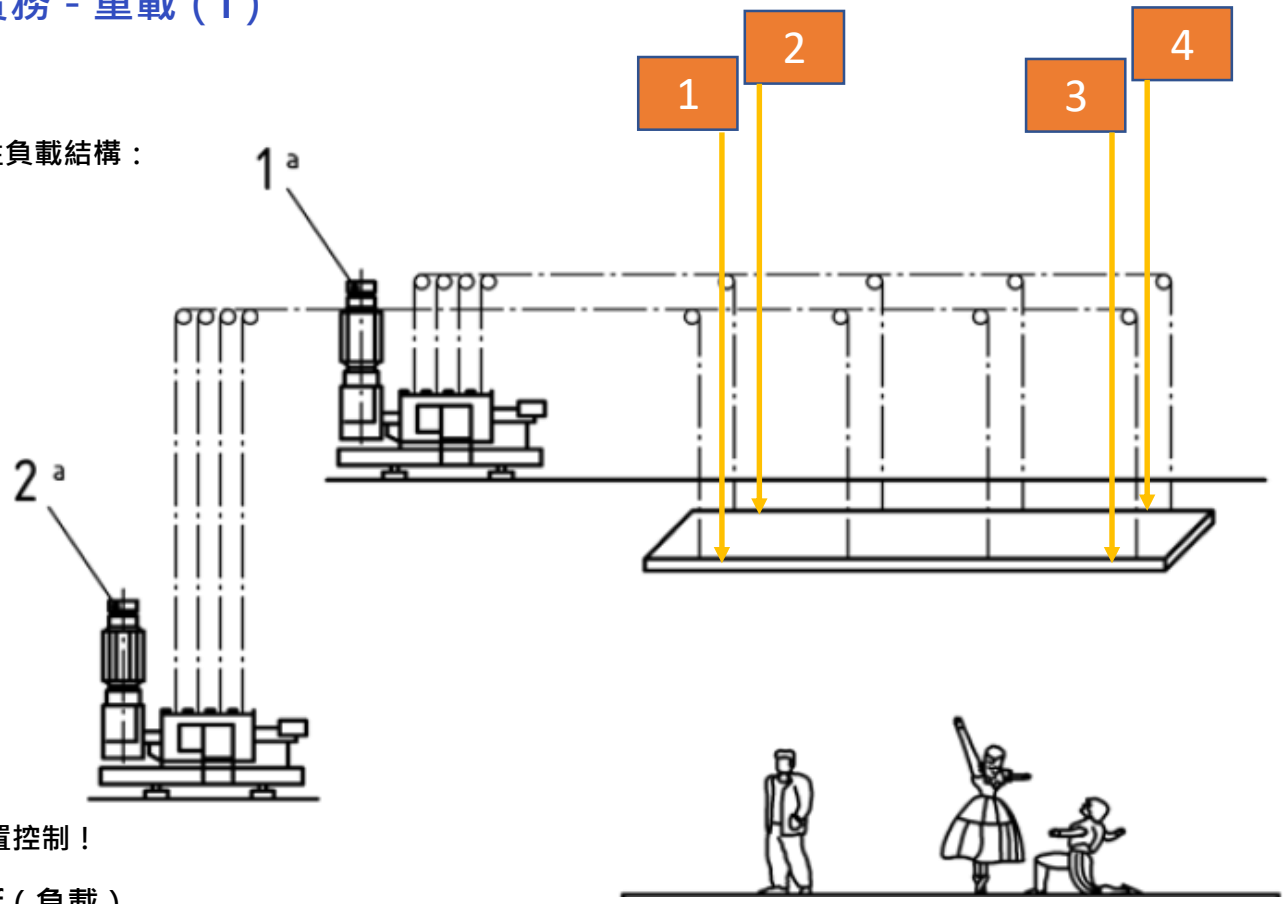
Soft structure of load with 4 pick-ups:

帶有4個傳感器的軟性負載結構：

→ statically (in)definite 靜態確定

→ 0,9 x payload per lifting equipment

→每台起重設備的有效載荷為0.9倍



- Variable speed hoists: Position control! 變速提昇機：位置控制！
- Fixed speed hoists: speed = f(load) 定速提昇機：速度= f (負載)

Safety of Machinery + Functional Safety 機械安全+功能安全

Ingenieurbüro

Best practise – Heavy loads (II) 最佳實踐- 重載（II）

- Best practice: Batten Clew 最佳實踐：Batten Clew 吊桿載重連結器

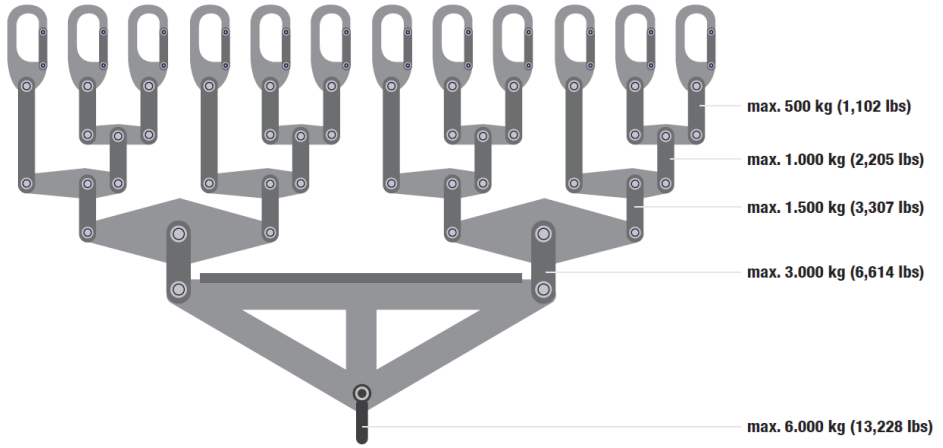
Batten Clews allow heavy loads to be evenly distributed over several pipe battens
Batten Clews 允許重載均勻分佈在幾個吊桿上

→ Ensure control system synchronisation 確保控制系統同步

→ Be aware of displacement of pipe battens + center of gravity 注意吊桿的位移+重心

→ Be aware of maximum deviation in case of failure 如果發生故障，請注意最大偏差

→ Check travel height 檢查行程高度



Thank you for your attention 感謝您的關注

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