



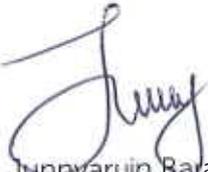
**PETRONAS**

# **WELL INTEGRITY MANAGEMENT GUIDELINES**

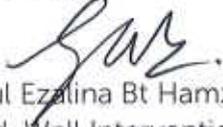
Supplementation to PPGUA 4.0 Vol 7, Section 8.6

Prepared By,

  
28/5/2018  
Mohd Azli Bin Maaris  
Well Intervention Engineer  
Well Management, Resource Management  
Malaysia Petroleum Management  
Date :

  
28/5/2018  
Junnyaruin Barat  
Executive, Well Integrity  
Wells Department  
COE/Upstream  
Date :

Reviewed by:

  
Nurul Ezalina Bt Hamzah  
Head, Well Intervention  
Wells Management, Resource Management  
Malaysia Petroleum Management  
Date : 4/6/2018

  
M Yuzmanizeil B Yaakub  
Principal, Well Intervention  
Wells Department  
COE/Upstream  
Date : 4/6/2018

Endorsed by,

  
M Zulkifli Zakaria  
Head, Wells Management  
Resource Management  
Malaysia Petroleum Management  
Date : 4/6/2018

Approved by,

  
Aidil Shabudin  
Head  
Resource Management  
Malaysia Petroleum Management  
Date : 28/6/2018

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## Summary

This document is applicable to all well types which are in operation, shut in, suspended or temporarily abandoned. Wells which are under construction or permanently plugged and abandoned are not covered by this guideline.

The Well Integrity Management Guidelines (WIMG) is a supplement to PPGUA 4.0 Volume 7, Section 8.6 (Well Integrity Management). The other requirements not specified herein are to remain unchanged.

Well Integrity Management Guideline (WIMG) is established to meet the following objectives:

- a. To fulfill PETRONAS commitments towards HSE.
- b. To drive pro-activeness in managing the well integrity.
- c. To minimize value leakage due to deferred production caused by idle well with integrity issues.
- d. To promote a level of consistency amongst PACs when evaluating the well integrity by having a standard reporting on well integrity performance.
- e. To ensure the PACs well integrity performance/ activities are in accordance to the WPB commitments and PETRONAS strategic planning.

WIMG consists of three (4) main elements:

- a. Well Integrity Categorization
- b. WIMG Key Performance Indicator (KPI)
- c. Well Integrity Performance Monitoring
- d. Well Integrity Remedial Work Approval Requirement

WIMG is included as a sub-element in the Total Well Management (TWM) to further strengthen the objective of TWM which is to arrest further value leakages and maximize the value addition to PETRONAS and PACs.

## 1 Well Integrity Categorization.

The well Integrity categorization approach is done as per string basis and based on the compliance to the barrier policy outlined in PPGUA 4.0 Volume 7, Section 8.3 (Number of well Barriers). The categorization should reflect the current condition of the well and utilizes a (4) four category system - a green/yellow/orange/red traffic-light-color-coded system for visualization purpose. The principles and color designation for the different categories are as follows:-

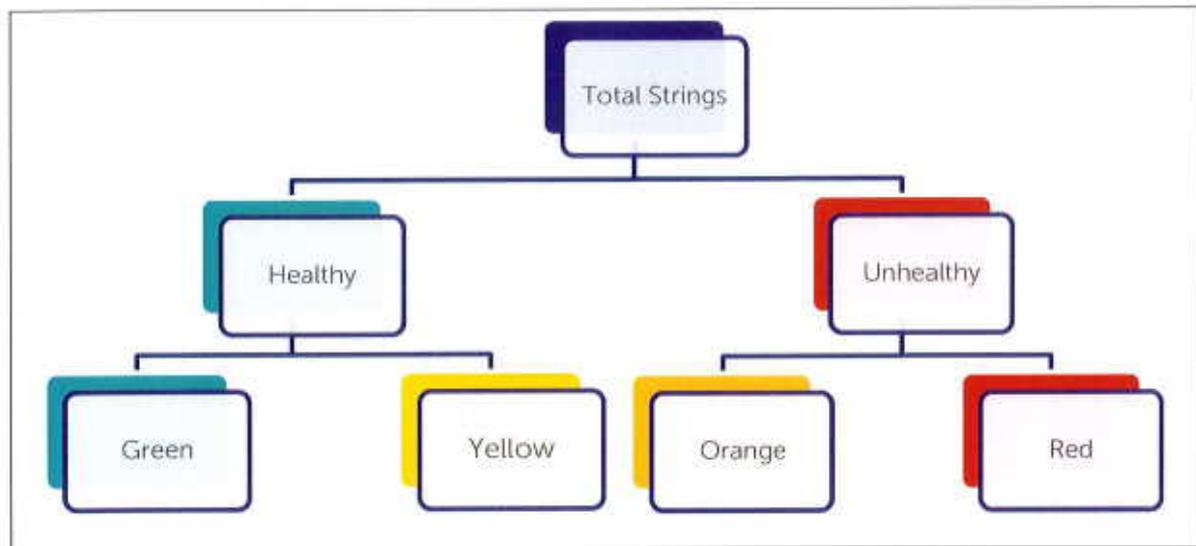


Figure 1: Well Integrity categorization

Main Category	Sub-category	Principle
Healthy	Green	Healthy well i.e. no or with minor issues
	Yellow	One barrier degraded, the other is intact
Unhealthy	Orange	One barrier failure and other is intact, or a single failure may lead to leak to surface
	Red	One barrier failure and the other is degraded/not verified, or leak to surface. Repairs and or mitigation will be required before the well can be put into operation or made safe and there will usually be an immediate and urgent need for action.

Figure 2: Well Integrity Principle.

Defining an acceptance limit is outside of the scope of this guideline, and is left to the discretion of the individual PAC as approved by PETRONAS in Well Integrity Management System (WIMS). In the following sections, the categories will be described in more details and different conditions which usually fall into the different categories will be addressed in the APPENDIX.

## 2 WIMG Key Performance Indicators (KPIs)

The WIMG KPIs are designed to drive prudent management of well integrity matters as well as an aid to:

- Ensure PACs fulfill the WPB commitments
- Determine the effectiveness of the PACs WIMS as currently implemented.
- Support pro-activeness in arresting numbers of well with integrity issues.
- Minimize the impact of unplanned production deferment due to well integrity issues.

The overall WIMG KPIs are shown in Figure 3 below. Each field might have different target of KPI that endorsed by PETRONAS during the annual Asset Management Integrated Review (AMIR). The examples provided are for illustration purpose only.

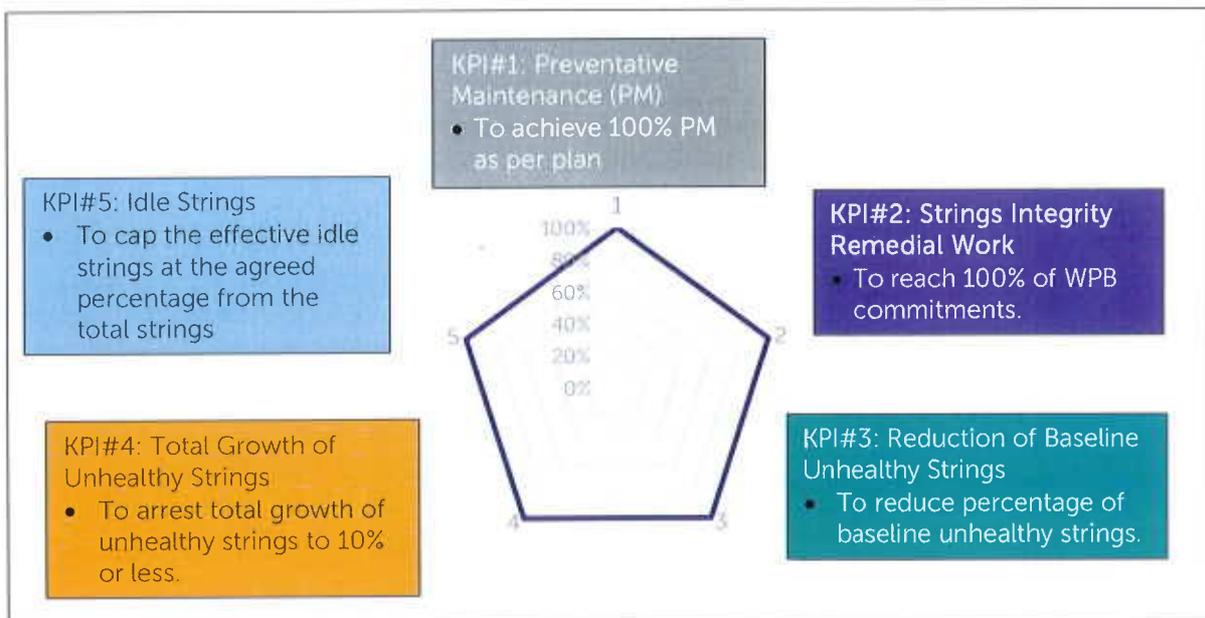


Figure 3: WIMG KPIs and Targets

## 2.1 Key Performance Indicator #1 for Preventive Maintenance

As part of Well Integrity Management System or maintenance guideline established, preventive maintenance shall be completed twice yearly or as per frequency defined by each PAC and approved by PETRONAS. Every PAC should inform PETRONAS on number or frequency of preventive maintenance as part of the monitoring and tracking process. PACs will update to PETRONAS the number of the preventive maintenance completed on monthly basis.

### Example of KPI#1

In any particular engagement, PAC B has informed PETRONAS that they have a total of 100 preventive maintenances (basis: 50 wells) that need to be completed on yearly basis and PAC B already completed 64 preventive maintenances. Thus, PAC B already completed 64% of their yearly preventive maintenance program.

Result	64%
Performance Score	64 %

Performance Rating KPI#1	Red: <40%
	Yellow: 40 % - 99%
	Green : = 100%

## 2.2 Key Performance Indicator #2 for Well Integrity Remedial Work

The objective of this KPI is to ensure 100% execution of WPB commitment. The number of strings planned to be rectified next year shall be agreed during AMIR session or other-engagements with PETRONAS and the endorsed plan will be the basis for the WPB request.

Formula below explains the calculation for KPI#2.

$$KPI\#2 = \frac{\text{Actual WPB plan job completed}}{\text{Total WPB job planned}} \times 100$$

### Example of KPI#2

In the WPB submission, PAC B has committed to execute remedial work for 100 strings with integrity issues. At the time of evaluation, PAC B has already rectified 86 strings with integrity issues that was planned in WPB. Thus, PAC B only completed 86 % of their WPB commitment and still not meet the KPI #2.

$$KPI\#2 = \frac{86}{100} \times 100 = 86 \%$$

Result	86%
Performance Score	86%
Performance Rating	Red : < 40%
KPI#2	Yellow : 40-99 %
	Green : = 100 %

## 2.3 Key Performance Indicator for Unhealthy Strings

Strings with integrity issues require additional monitoring to manage the associated risks. To ensure PACs give a priority in managing the number of unhealthy strings, two (2) key performance indicators have been established.

KPI#3 Reduction of Baseline Unhealthy Strings.

KPI#4 Total Growth of Unhealthy Strings.

### 2.3.1 Key Performance Indicator #3 for Reduction of Baseline Unhealthy Strings

The KPI is set to measure the effectiveness of the remedial approach taken to eliminate integrity issues within twelve (12) months or per yearly basis. Any remedial action taken on the strings with integrity issues but unable to sustain for more than 12 months should remain as baseline of unhealthy strings by end of the financial year.

The target percentage is set at the beginning of the year (or during AMIR). Formula below explains the calculation for KPI#3 assuming the target is 10%.

$$KPI\#3 = \frac{\text{Number of unhealthy baseline strings managed to be rectified}}{\text{Baseline number of unhealthy strings}} \times 100$$

#### Example of KPI#3

At any particular time, PAC B has a remaining of 98 unhealthy baselines strings (within orange and red category) with integrity issues compare to 100 strings during the agreed cutoff date. Thus, the reduction of unhealthy baseline strings is 2 % and not meeting KPI#3.

$$KPI\#3 = \frac{2}{100} \times 100\% = 2\%$$

Result	2%
Performance Score	50 %

Performance Rating KPI#3	Red: no reduction	0%
	Yellow: 1 % to 9%	50%
	Green : >= 10%	100%

### 2.3.2 Key Performance Indicator #4 for Total Growth of Unhealthy Strings

The objective of the KPI#4 is to support pro-activeness in arresting numbers of unhealthy strings to 10 % or less. Formula below explains the calculation for KPI #4

$$KPI\#4 = \frac{\text{Current growth of Unhealthy strings}}{\text{Total string exclude full abandonment}} \times 100$$

#### Example of KPI#4

At any particular time, 18 additional strings have become unhealthy and it is recorded that current PAC total strings is 200. Thus, the percentage of growth is 9% and still meets the KPI#4 to cap the unhealthy growth at <10%.

$$KPI\#4 = \frac{18}{200} \times 100\% = 9\%$$

Result	9%
Performance Score	100 %

Performance Rating KPI#4	Red: > 30%	0%
	Yellow: 11 % to 30%	50%
	Green : =< 10%	100%

## 2.4 Key Performance Indicator #5 for Idle Strings

The objective of the KPI#5 is to minimize the impact of unplanned production deferment due to well integrity. The effective idle strings due to integrity is capped at an agreed percentage which will be discussed and agreed at the beginning of the year (or AMIR review).

Formula below explains the calculation for KPI#4 assuming that the target is to cap the effective idle strings to 2%.

$$KPI\#5 = \frac{\text{Number of effective idle due to integrity}}{\text{Total Strings exclude full abandonment}} \times 100$$

### Example of KPI#5

At any particular time, PAC B has 16 effective idle strings due to integrity issue while having 1000 total strings. Thus, PAC B has 1% of effective idle due to integrity and still meets PETRONAS expectation not to exceed 10% of strings shut in due to integrity.

$$KPI\#5 = \frac{16}{1000} \times 100 \% = 1.6\%$$

Result	1.6 %
Performance Score	100 %

Performance Rating KPI#5	Red: >50%	0%
	Yellow: 3 % to 50%	50%
	Green : =< 2%	100 %

## 2.5 WIMG as A Part of Total Well Management (TWM)

The main objectives of Well Management Key Performance Indicator (KPI) are to enhance HSE performance, well integrity assurance, arrest further value leakages and maximize value addition from well assets in Malaysia to PETRONAS and its Petroleum Arrangement Contractors (PACs). The KPI are set to ensure PACs meet the inspiration and strategic planning of TWM.

The updated TWM includes the well Integrity element which will further strengthen the objective of TWM. In order to include the WIMG KPIs together with TWM KPIs, a single parameter is introduced by averaging the performance score of WIMG KPIs.

### 2.5.1 Example of Averaging WIMG KPIs

Example below illustrates how averaging the WIMG KPI is affected in the TWM KPI.

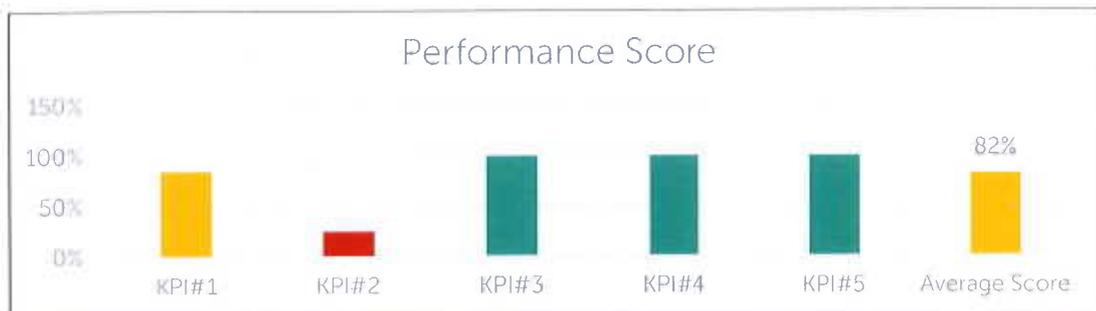


Figure 4: Example of Averaging WIMG KPI

Once the WIMG KPI's are averaged, a single percentage will be further ranked.

Average Score	Remarks
78-100%	PAC has showed prudent performance in managing the well integrity.
40-78%	PAC need to put extra effort in order to improve and reach the PETRONAS aspiration.
0-40%	PAC has showed poor performance in managing the well integrity. Strong collaboration with PETRONAS is needed to improve

TWM KPIs as affected by the WIMG average score KPI.

	TWM KPI	Target
KPI #1	TP Enhancement from Active Strings	TBA
KPI#2	Arrest Idle Strings Growth	
KPI#3	Unlock LIP from EI Wells	
KPI#4	Idle and Abandonment Wells Time bound Limit	
KPI#5	PE/IWR Success rate	
KPI #6	Well Integrity Management	>= 70%

### 3 Well Integrity Performance Monitoring.

The elements of reporting submitted by PACs has been covered by PPGUA 4.0 Volume 7 Section 8.6. This section covered well integrity status, SCP status and tracking, and well integrity remedial plans.

By using a standard well integrity categorization a consistent approach to evaluating the integrity of the well shall be established amongst the PACs. By using WIMG KPIs, PACs shall acknowledge which KPI needs to be improved further and which shall be maintained.

PACs are require to provide monthly update their well integrity performance through the Online Data Performance (ODU) at <https://odu.petronas.com/ODU64/Account/Login>. The visual results of the well integrity performance by each PAC is available at Online Drilling Benchmarking System (ODBS) at <https://va.petronas.com/SASLogon/login>

## 4 Well Integrity Remedial Approval Requirement

This guideline is aimed to empower PACs in managing their well integrity work.

PETRONAS approval for any well integrity remedial is required when:

- a) Estimated job cost is greater than RM 1 million
- b) The activity involved remedial cementing behind the casing(s) to remediate sustained annulus pressure.
- c) Integrity issues that require abandonment of zones of well to be resolved.
- d) Work that is rated as high risk or very high risk before mitigations.

As prudent operators, PACs are expected to carry out due diligence from all the aspects of the remedial job which shall cover the following activities:

- a) Availability of correct and sufficient data about the well and production parameters.
- b) Lab tests or other relevant tests, if required.
- c) Selection of the right technique/ technology.
- d) Risk identification, analysis and identification of mitigation methods.
- e) Proper planning of the activity and mitigation of execution risk.
- f) Execution of the activity as per plan.
- g) Utilization of previous experience or lessons learned.

## 5 Implementation

Well Integrity performance and KPI will be discussed at field level during the annual Asset Management Integrated Review (AMIR) process.

PACs are expected to propose targets to be achieved for the incoming year which will be reviewed and endorsed by PETRONAS during AMIR process. The same target proposed will also be used as justification for the Work Program & Budget (WPB) approval.

Actual performance against target is presented and reviewed with PETRONAS during the subsequent yearly AMIR review session.

## 6 Appendix

### Definition of Well Integrity Categorization and Terms

General Description	Healthy		Unhealthy	
	Green	Yellow	Orange	Red
Sub Principle	Healthy well - no issues or minor issues	One barrier degraded, the other is intact	One barrier failure and other is intact, or a single failure may lead to leak to surface	One barrier failure and the other is degraded/not verified, or leak to surface
Associated Risk	Comparable to that of an identical new well with design in compliance with regulation	Incremental/ associated risk which is not negligible compared to the risk associated with an identical new well with a design that complies with all regulations	higher than the risk associated with an identical new well with a design that complies with all regulations	Considerably higher than the risk associated with an identical new well design that complies with all regulations
Compliance with regulation	it does not necessarily mean that the well has no history of leak, or that the WBE has not fulfilled the all acceptance criteria in WMS, but the well is in full compliance with the double barrier requirement.	Conditions are within PPGUA requirements, or deviation from PPGUA has been approved by MPM.	Typically will be outside the PPGUA requirement.	Typically will be outside the PPGUA requirement.
Risk of Dual Barrier Failure (degradation, corrosion, etc)	The well SHOULD NOT be categorized as green if a condition exists which constitute a considerable threats to both barrier and risk of dual barrier to fail	The well will still have an intact barrier and there will usually not be an immediate and urgent need for action.		Repairs and or mitigation will be required before the well can be put into operation or made safe and there will usually be an immediate and urgent need for action.
Typical Action	Typically does not require any immediate repairs or mitigation measures (in addition to the ones that may already performed and implemented)	No action is required, monitoring of the well is needed, if there is a leak then the source of the leak needs to be identified. MOC is not required.	MOC is allowed with time bound limit. Required dispensation approval from MPM if condition does not meet the PPGUA requirement.	MOC and dispensation approval is not allowed.

#### Definition of terms

1. Degraded : Signs that there are problems with a barrier but it has not yet definitely failed and it should function as barrier.
2. Baseline number : Strings count as of 31<sup>st</sup> Dec (end of year).
3. Growth : New register string that occur /register in the current year.

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