

## Methods of port state control assessment of ships flying a specific flag

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**Key words:** Paris Memorandum of Understanding, inspections of Port State Control, black list, grey list, white list, methods of calculation, risk

### Abstract

This study discusses the principles and methods of assessment based on Port State Control inspections of various flag ships. These inspections are aimed at checking to what extent international convention requirements concerning navigational safety and marine environment protection are fulfilled. This study makes use of annual statistical reports of the Paris Memorandum of Understanding, and incorporates the author's presentation of calculating methods, on which the assessments of the national merchant vessel fleets are based.

### Introduction

The Paris Memorandum of Understanding established in 1982 was an agreement [1] of the most developed maritime states of Western Europe, aimed at creating a control system (Port State Control (PSC) – performed by inspectors of the port state) [2] for ships of various flags calling at their ports, in order to verify the standards of navigational safety maritime environment protection and working conditions of the crews. Initially, the Paris Memorandum of Understanding associated 14 states (Belgium, Denmark, Finland, France, Greece, Spain, the Netherlands, Iceland, Germany, Norway, Portugal, Sweden, Great Britain, Italy). Today there are 27 European states plus Russia and Canada.

Notably, the agreement of the above states triggered the establishment of equivalent organisations in other parts of the world: Asia and the Pacific Rim – Tokyo MoU, South America – Acuerdo de Viña del Mar, the Caribbean MoU, Western and Central Africa – Abuja MoU, the Black Sea MoU, the Mediterranean MoU, Indian Ocean MoU; the Persian Gulf – Riyadh MoU, the United States Coast Guard – Department of Homeland Security [3].

Poland acceded to the Paris Memorandum of Understanding in 1992. Legal regulations govern-

ing the activities of PSC are set forth in official EU documents and national legal acts:

1. Directive of European Parliament and of the Council 2009/16/EC of 23 April 2009 on Port State Control (Official Journal of the European Union L 131/57 of 28.05.2009) [4] which went into force on 1 January 2011. The document replaced the previous directive 95/21/EC.
2. Commission Regulation (EU) No. 428/2010 of 20 May 2010 implementing Article 14 of Directive 2009/16/EC of the European Parliament and of the Council as regards extended inspections of ships (Official Journal UE 125 of 21.05.2010) [5], which is in fact a supplement to the above directive.

The most essential national documents are:

1. Act on maritime safety of 18 August 2011 (Journal of Laws of 24 October 2011, nr 228 item 1368) [6], and
2. Regulation of the Minister of Transport, Construction and Maritime Economy of 28 March 2012 on port state control (Journal of Laws of 29 of May 2012, item 597) [7].

The above documents mainly address the requirements concerning the safety of life at the sea [3, 8, 9], the protection of marine environment

(mainly International Convention on the Safety of Life at Sea: SOLAS 74/78/89, and MARPOL 73/78) and other conventions connected with the problems herein discussed (STCW 78/97, COLREGS 72, Loadline 66/88, Tonnage 1989).

The essence and purpose of PSC is to control the execution and implementation of regulations and provisions of the Paris Memorandum of Understanding and EU directives which are aimed at the improvement of navigational safety and marine environment protection. Parties to MoU demonstrate to Inspectorates of State Port control that the above mentioned legal regulations are confirmed by their own national documents. In Poland their offices are located in Gdynia, Gdańsk, Słupsk, Szczecin and Świnoujście.

The areas of PSC inspections of foreign flag ships cover:

1. The safety of navigation, verifying if:
  - the ship has the required documents and certificates;
  - the crew is manned and competent;
  - alarm drills are arranged – all personal qualifications are checked as well as whether procedures of life saving appliances and equipment are observed;
  - the hull and equipment of a ship is in good technical condition;
  - MARPOL Convention provisions are observed;
  - ship's personnel can work in safe conditions;
2. Drawing up inspection reports and entering them into the system data base THETIS (The Hybrid European Targeting and Inspection System) [10].

The types of inspections include:

- a) Initial Inspection;
- b) More Detailed Inspection;
- c) Expanded Inspection.

**Initial inspection** establishes the extent of the implementation of basic requirements imposed by IMO Conventions or other organizations and may be a basis for conducting a more **detailed inspection**.

**Expanded inspection** – refers to ships of high risk profile: sea going tankers and passenger ships as well as bulk carriers older than 12 years and vessels subject to re-inspection (access to port banned).

Since 1 January 2011 the new inspection regime (New Inspection Regime) has been in operation in ports covered by the Paris MoU. The new system consists of six points:

1. All vessels are subject to control. By 2011 the obligation covered only 25% of ships calling at ports of the Paris MoU.
2. Attributing each ship a risk profile which directly translates into the inspection free time span:
  - High Risk Ship (HRS) 5–6 months;
  - Standard Risk Ship (SRS) 10–12 months;
  - Low Risk Ship (LRS) will be inspected every 2–3 years.
3. Risk profiles attributed to each vessel may have an extended scale and include Very Low Risk (very low level of hazards). The black list also distinguishes very high risk, when the level of hazards expressed by the excess factor (EF) is very high.
4. Categories of inspections, time span between inspections, priority I and priority II, types of inspections:
  - ships with priority I have to undergo an inspection;
  - 85% of ships with priority II are controlled.

The time span between the inspections may be closed, which means there is no priority assigned. This does not mean, however, that the ship cannot be controlled. The new system allows to change the priority if such need has arisen.

Inspection categories indicate the periods between inspections (see p. 2), also additional ones that will be performed in case of unexpected circumstances.

5. Banning, that is refusal of access to a port of member state of MoU. Banning refers to all types of ships. The new inspection regime has extended its application and banning may affect ships:
  - on the grey list which in Paris MoU ports have been detained within the past 2 years,
  - on the black list within a period of not longer than 3 years.

6. Reporting  
The new system has extended the obligation to report ETA (Estimated Time of Arrival) 72 hours in advance on vessels undergoing an expanded inspection as well as high risk ships, tankers, passenger ships and vessels older than 12 years.

The THETIS system is a source of information for the purpose of inspections; it is a database for the port state inspectorate; the base is administered by the EMSA (European Maritime Safety Agency) [11].

This up-to-date and effective program strictly cooperates with the European Safety of Navigation System (SafeSeaNet) and is available round the clock, seven days a week for all PSC offices in Paris MoU member states.

THETIS includes all the vessels and risk profiles attributed to them – LRS, SRS, HRS (low, standard, high) and defines the time span for the next inspection.

Since 1999 annual reports of the Paris MoU provide black, grey and white lists based on three year quality area of assessment of vessels under a given state flag.

The above lists are based on ship assessment calculations for a given state flag and make use of mathematical formulas commonly used in statistics. The results are reliable indicators of the performance of given flag state vessels and their conformity with the policy of the Paris MoU.

The formulas below represent methods of calculations in the new system of two limits: black-to-grey and grey-to-white:

$$u(\text{black to grey}) = N \cdot p + 0.5 + Z \sqrt{N \cdot p (1 - p)}$$

$$u(\text{grey to white}) = N \cdot p - 0.5 - Z \sqrt{N \cdot p (1 - p)}$$

where:

$N$  – number of inspections;

$p$  – allowable limit of detentions, set to 7% by the Paris MoU PSC Committee;

$Z$  – required significance ( $z = 1.645$  for a statistically acceptable confidence level of 95%);

$u$  – allowed number of detentions for either the black or the white list.

A number of detentions above this ‘black to grey’ limit means significantly worse than average, while a number of detentions below the ‘grey to white’ limit means significantly better than average.

If the number of detentions for a specific Flag is positioned between the ‘black to grey’ and ‘grey to white’ limits, the Flag ranks on the intermediate grey list. The above formulas are applicable for a sample sizes of 30 or more inspections over a three year period.

If we want to sort the results on the white or grey list, we have to change the target and make calculations again. In the process, the set 7% detention limit can be increased or decreased by 3% increments. Calculations can be repeated to get the required accuracy. Typically flags that are still significantly above that the second target are worse than the flags which are not above. To make the Flags’ performance comparable, the excess factor (EF) is introduced. Each incremental or decremental step corresponds with one whole EF-point of difference. Thus the EF is an indication for the number of times the yardstick has to be altered and recalculated.

Once the excess factor is determined for all flags, the flags can be ordered by the EF. The three lists, White, Grey and Black, include in the last column excess factors, calculated with the principles given above.

Relations between the number of inspections and detentions can be illustrated graphically (Fig. 1). The two axes have a logarithmic character as the ‘black to grey’ and ‘grey to white’ limit.

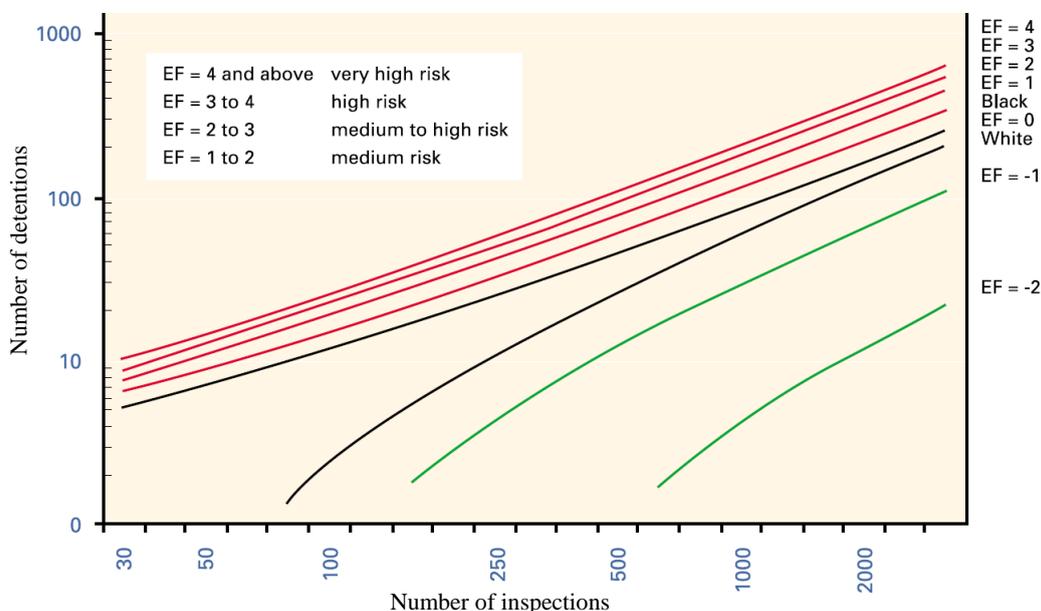


Fig. 1. Relations between the number of inspections and detentions [12]

The indicated EF values indicate approximate relations of the number of inspections and resultant detentions as well as the risk profile of a specific flag ships.

### Calculations of the Excess Factor (EF)

#### A. Example calculations for the black list

Flag A ships were subjected to 108 inspections, of which 25 resulted in detentions. The ‘black to grey’ limit is calculated to be 12 detentions. The reported EF is 4.6,  $N$  – number of inspections,  $p$  – allowable detention limit set to 7% of limit increment  $q = 3\%$ ,  $Z$  – statistical constant,  $u$  – allowable limit of detentions. The number is calculated as follows:

$$u = N \times p + 0.5 + 2 \sqrt{N \times p \times (1 - p)}$$

$$u = 108 \times 0.07 + 0.5 + 1.645 \sqrt{108 \times 0.07 \times 0.93} = 12$$

The excess factor equals 4.26. This means that ‘ $p$ ’ has to be adjusted in the formula. The ‘black to grey’ limit is 1, so to determine the new value for ‘ $p$ ’, we have to multiply ‘ $q$ ’ by 3.26 and the outcome has to be added to the normal value for ‘ $p$ ’:

$$p + 3.26 \times q = 0.07 + (3.26 \times 0.03) = 0.1678$$

therefore,

$$u = 108 \times 0.1678 + 0.5 + 1.645 \sqrt{108 \times 0.1678 \times 0.8322} = 25$$

It can be observed that the result is above the limit of detention.

Annual reports do not provide further mathematical procedures for the given excess factors, let us follow the calculations of these indicators, vital enough to be used as a criterion for making separate lists of the ship flags. First, the new value of detention limit ‘ $g$ ’ has to be increased by 3%:

$$a) \quad p = 7\% \quad p^1 = p + q = 7\% + 3\% = 10\% \\ q = 3\%$$

$$u^1 = N \times p^1 + 0.5 + Z \sqrt{N \times p^1 \times (1 - p^1)}$$

$$u^1 = 108 \times 0.10 + 0.5 + 1.645 \sqrt{108 \times 0.10 \times (1 - 0.10)} = 16.78 \text{ (detentions)}$$

$$\text{EF } 1 + 1 \text{ (number of limit alterations)} = 2$$

$$u^1 = 16 \text{ detentions}$$

b) calculating further by 3% increments we obtain:

$$n = 16$$

$$N = 108$$

$$p^2 = p^1 + q = 10\% + 3\% = 13\%$$

$$\text{we get } u_2 = 20.2 \text{ detentions and } \text{EF} = 1 + 2 = 3$$

c) another 3% increment will yield:

$$p^3 = p^2 + q = 16\%$$

$$\text{EF} = 1 + 3 = 4$$

$$u_3 = 24 \text{ detentions}$$

d) in the final step, another increment by 3%:

$$p^3 + q = 19\% \text{ we obtain}$$

$$u^4 = 27 \text{ detentions}$$

$$\text{EF} = 1 + 4 = 5$$

$$27 > 25.$$

To calculate the excess factor for 25 detentions, we compare from the formula:

$$u = N \times p^1 + 0.5 + 2 \sqrt{N \times p^1 \times (1 - p^1)}$$

$$(N \times p^1 + 0.5 - u)^2 = 2^2 \times N \times p^1 (1 - p^1)$$

calculating  $p^1$  from this equation:

$$p^1 = 0.16$$

$p^1 = p + l \times q = p + (\text{EF} - 1)q$ , where  $l$  – number of 3% increments.

$\text{EF} = \frac{p^1 - p}{q} + 1 = 4.26$  – indicates a very high risk profile (see Fig. 1).

#### B. Example calculations for the grey list

Usually, flags B were the subject of 141 controls which resulted in 10 vessels detained. The ‘black to grey limit’ is 15, and the ‘grey to white limit’ is 4. The excess factor is 0.54 (author’s calculations). The method of determining the black to grey limit is shown below:

$$u \text{ (black to grey)} = N \times p + 0.5 + 2 \sqrt{N \times p \times (1 - p)}$$

$$u = 141 \times 0.07 + 0.5 + 1.645 \sqrt{141 \times 0.07 \times (1 - 0.93)}$$

$$u = 15$$

$$u \text{ (grey to white)} = N \times p - 0.5 - 2 \sqrt{N \times p \times (1 - p)}$$

$$u = 141 \times 0.07 - 0.5 - 1.645 \sqrt{141 \times 0.07 \times 0.93}$$

$$u = 4 \text{ number of detentions within the grey limit.}$$

The estimation of the excess factor (according to the previous example):

$$\text{EF} = \text{number of detained ships} - (\text{grey-to-white}) = (10 - 4)$$

$$(\text{grey-to-black}) - (\text{grey-to-white}) = (10 - 4)$$

$$\text{EF} = (10 - 4) / (15 - 4) = 6 / 11$$

$$\underline{\text{EF} = 0.54}$$

The excess factor 0.51 given in the example calculations of the Annual Report 2012 is not exact, as  $6 / 11 = 0.54$ .

#### Example of a white listed flag

Ships flying the flag C were subject to 2652 inspections, and as a result 104 ships were detained.

The 'grey to white' limit is 164 detentions, EF is equal to  $-0.80$ . Here is the way the 'grey to white' limit is determined:

$$u = N \times p - 0.5 - 2\sqrt{N \times p \times (1 - p)}$$

$$u = 2652 \times 0.07 - 0.5 - 2\sqrt{2652 \times 0.07 \times 0.93} = 164$$

EF is  $-0.80$ . This means that ' $p$ ' has to be adjusted in the formula. The grey to white limit has an excess factor of 0, so to determine the new value for ' $p$ ' ' $q$ ' has to be multiplied with  $-0.8$  and the outcome has to be added to the normal value for ' $p$ ':

$$p^1 = p + (-0.80 \times q) = 0.07 + (-0.80 \times 0.03) = 0.046$$

Putting the new value of  $p$ :

$$u = 2652 \times 0.046 - 0.5 + \\ -1.645\sqrt{2652 \times 0.046 \times 0.954}$$

we get  $u = 104$ , a result that places the flag on the white list.

Therefore, the excess factor will be calculated as follows:

$$u = N \times p - 0.5 - 2\sqrt{N \times p \times (1 - p)}$$

transformed to the form:

$$2^2 \times N \times p^1 (1 - p^1) = (N \times p^1 + 0.5 - u)^2,$$

gives a basis for calculating  $p^1$ :

$$p^1 = p + EF \times q = 0.046$$

$$EF = \frac{p^1 - p}{q} = \frac{0.046 - 0.07}{0.03} = -0.80$$

## Conclusions

These simple calculations are convincing, reliable, verifiable and comparable, an effective tool for risk analysis and assessment performed to enhance the safety of navigation. When familiar with the methods of calculations placing ships on a black, grey or white list, the ships crews but mainly ship operators, captains and officers should be aware of the impact that compliance with international and national regulations define as their flag is seen on the world shipping market.

Statistical annexes of the annual report, with all the facts and figures, provide rankings of safe and unsafe state flags, illustrating the white, grey and black lists with a spectrum of tables and diagrams, informing of the inspection efforts of MoU member states.

The clearly arranged data derived from accurate calculations give an insight into positions of individual flag states. The ranking translates into economic effects when it comes to cargo freight acquisition where a guarantee of safe carriage by the sea is an essential factor.

PSC inspections also bring data for the assessment of organizations related to the ships as institutions responsible for the technical supervision of ships under construction and those in service. Classification societies are accountable for the ship's fulfillment of international requirements when a class certificate is being issued, a proof that the ship is safe and seaworthy.

Due to the unfavourable legal regulations at home, Polish ship-owners reflagged their ships that presently sail under foreign flags. Thus they contribute to the ranking positions of such flags as the Bahamas, Cyprus and others. Nevertheless, ships of Polish ship-owners are subject to their own analyses, taking into consideration all the comments, deficiencies and detentions by PSC inspectors in various ports of the world.

PSC statistics of deficiencies and detentions also tend to group ships by shipowner, in the same way it is done by state flag.

The use of PSC records, containing extensive data from numerous inspections, indicating deficiencies understood as failure to satisfy international and national regulations by ships flying a specific flag, allows to take preventive actions by shipowners, and to adjust curricula of maritime universities.

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