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DETERMINATION OF EMERGENCY SOURCE OF ELECTRICAL POWER CAPACITY FOR SHIPS WITH RESTRICTED SERVICE STUDY CASE ON SHIPS OPERATED IN INDONESIAN WATERS

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ABSTRACT

The Safety of Life at Sea (SOLAS) requires that all ocean-going ships of 500 GT and upward should be designed so that in case of distress condition which may lead to the dead ship, a sufficient capacity of an emergency source of electrical power (ESEP) should be available onboard ship. The ESEP should be capable to supply the equipment in emergency conditions, for instance to navigation and communication equipments, emergency lightings, emergency fire-fighting etc., for at least 18 hours for cargo ship and at least 36 hours for passenger ship. However, for ships having restricted service are not required to comply with such SOLAS regulation. In this case, the capacity of ESEP should be defined and might be reduced. The capacity of ESEP relies on several factors which will be further elaborated in this paper. It is logically being expected that the capacity of ESEP for restricted service ships is lower than those required one.

Keywords : *SOLAS; dead ship; emergency source of electrical power*

1.0 INTRODUCTION

As required by SOLAS regulation II-1/42 and 43 that every passenger and cargo ships shall be provided with a self-contained emergency source of electrical power (ESEP). The available ESEP shall be sufficient to supply all those services that are essential for safety in an emergency for a period of 36 hours for passenger ships and 18 hours for cargo ships. Furthermore, in a ship engaged regularly on voyage of short duration, the Administration, if satisfied that an adequate standard of safety would be attained, may accept a lesser period than those specified above but not less than 12 hours [1]. However, non-convention ships are not mandatory to comply with those requirements.

The non-convention Indonesian flagged ships are required by Indonesian Government to comply with the requirements of Classification Society for ships of 500 GT and above. As the Classification Society, Biro Klasifikasi Indonesia (BKI) are demanded to evaluate the safety precaution of all electrical installations, including verification of capacity of ESEP. As specified in the BKI's rules for classification and construction, especially Rules for electrical installations, ships are also required to provide with ESEP for those essential service in emergency. However, its capacity is not specified yet in the rules. This capacity may be lesser than those specified in SOLAS requirements

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in which depends on several factors such as the response time of SAR team, time required to transmit distress alert, time for embarkation during distress etc. Therefore, in this paper the capacity of ESEP for restricted service ship will be evaluated, particularly for those operated in Indonesian waters. Therefore, the output of this paper will be used as reference in determining the capacity of ESEP and as an input in developing of BKI's technical rules.

2.0 EMERGENCY SOURCE OF ELECTRICAL POWER (ESEP)

2.1 Capacity of ESEP

All cargo ships of 500 GT and over and all passenger ships are to be provided with a self-contained ESEP. It may be either a generator set or a storage battery. Where the ESEP is a generator set, it shall start up automatically if the main source of electrical power fails and, in any event, not later than 45 seconds after the failure of the main source of electrical power. The ESEP shall take over the supply of the emergency consumers in case of failure of the main source of electrical power. It shall be independent from the main source of electrical power. Meanwhile, its capacity shall be sufficient to supply all those services which are essential for safety in an emergency [2].

In determining the capacity of ESEP, there are several factors that need to be considered as specified in sub section 2.2. Those factors will vary for different type of accidents. Generally, the nature of ship's accidents is categorized as follow [9]:

- Missing
- Loss of control
- Hull failure
- Fire/Explosion
- Flooding/Foundering
- Collision
- Grounding/Stranding
- Capsizing/Listing
- Damage to ship or equipment
- Contact

The ESEP may come into operation depending on the ship conditions following the above accidents. However, it does not necessarily means that all of the above accidents may lead the ESEP to start working. For clarity, the operation of ESEP according to the type of accidents defined above is given in Table 1. The accident having greatest effect to the capacity of ESEP will be taken into account.

Table 1: Operation of ESEP based on type of accident

Nature of accident	ESEP start to service	Load to be supplied*	Duration	Remark
Loss of control				[1] If the main power source is out of service
– Loss of electrical power	Yes	1,2,5	Short	
– Loss of propulsion power	No	-	-	
– Loss of directional control	Yes [1]	1,2,5	Short	
– Loss of containment	No	-	-	
Hull failure	No	-	-	
Fire/explosion				[2] If the auxiliary engine including generator/s are damaged by fire /explosion
– In engine room	Yes [2]	2,3,4,5,6,7,8	Short – Long	
– In Other area	No	-	-	
Flooding/Foundering				[3] If the auxiliary engine

Nature of accident	ESEP start to service	Load to be supplied*	Duration	Remark
Flooding				including generator/s
– In engine room	Yes [3]	2,3,4,5,6,7,8	Short – Long	are out of service due to
– In other area	No	-	-	water ingress
Foundering	No	-	-	
Collision	No	-	-	
Grounding/Stranding	No	-	-	
Capsizing/Listing	No	-	-	
Damage to ship or equipment				[4] Auxiliary engine/s
– Damage of other equipment	Yes [4]	2,3,4,7,8	Short – Long	including generator/s
– Damage of system	No	-	-	
– Damage of ship	No	-	-	
Contact	No	-	-	
Missing	No	-	-	

*Note: 1. Equipment for starting A/E
2. Emergency lighting
3. Emergency lighting at every embarkation station
4. Fire detection and alarm system
5. Emergency fire pump
6. Bilge pump
7. Radio communication equipment
8. Navigation light and equipment

It is clearly shown in Table 1 that there are four kinds of accident which have to bring the ESEP into operation for supplying the electrical power to the essential service equipments as stated in the Note of the same table. Hence, the ESEP should have sufficient capacity to provide necessary power for emergency essential services until the Rescuer has arrived onboard for evacuation.

2.2 Factors affecting the ESEP capacity

During distress condition, the ship[1] is initiated to send a distress calls and/or messages in two ways of communication. The first one is by making use of DSC (digital selective calling) communication via shipborne radio communication equipment to other ships and/or shore stations SROP (Stasiun Radio Pantai) and the second one via Cospas-Sarsat satellite (a geostationary satellite intended for search and rescue) and/or aircraft by EPIRB (Emergency Position Indicating Radio Beacon).

In a brief period, transmitted distress calls/messages from distress ship will be received and acknowledged by standby SROP. Where these messages are received by other ship, they are not allowed to acknowledge such messages until SROP has acknowledged first. However, if after 5 minutes the distress alert is continuously present and it is supposed that the SROP do not received the distress message, thus other ship that receive distress message should relay the message to the nearest SROP. These messages will then directly be forwarded to the nearest SAR office to the accident location by SROP [3].

In case of using Cospas-Sarsat satellite, the sent distress message will be addressed to all Rescue Coordination Center (RCC), Marine Rescue Coordination Center (MRCC) and Mission Control Center (MCC) around the world. Once the message has been received, they will be delivered to the nearest SAR office for SAR operation. In Indonesia, it is called as BASARNAS (Badan SAR Nasional). The Figure 1 below shows the communication network during distress condition.

[1] Ships equipped GMDSS equipment

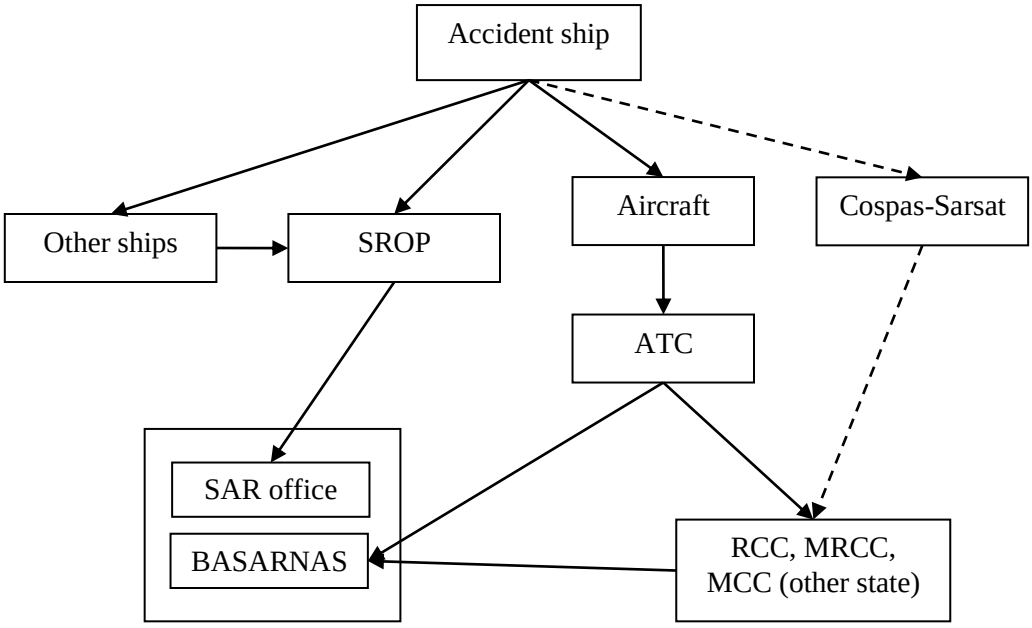

Figure 1: Distress communication network – BASARNAS [11]

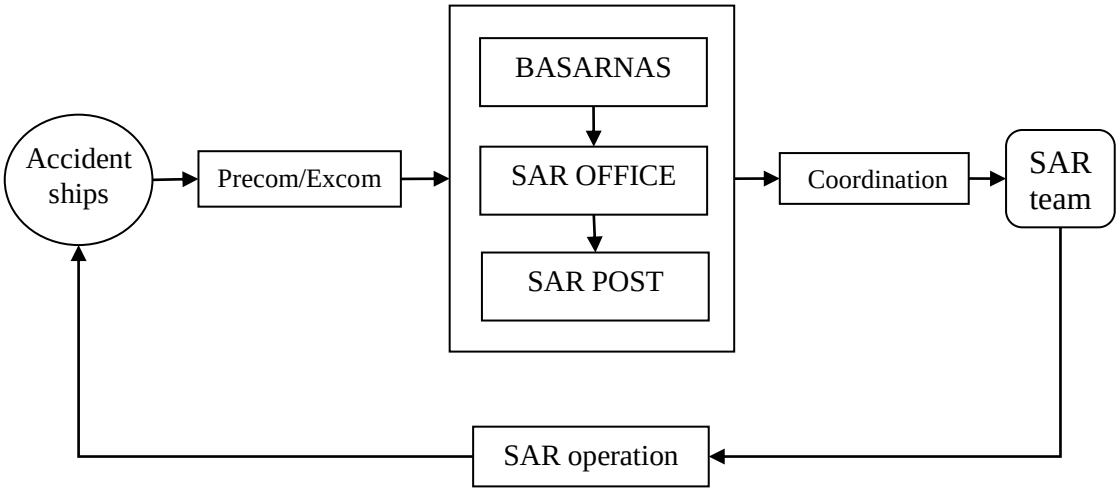

Figure 2: SAR operation stage of BASARNAS [12]

Referring to the Figures 1 and 2 above, it may be concluded that the capacity of ESEP is affected by the following factors:

1. Time required to transmit distress alert (T_{TR1})
2. Time required to acknowledge distress calls by coast stations (T_{ACT})
3. Time required to relay distress message to SAR office (T_{TR2})
4. Response time of SAR team (T_R)
5. Time required for rescue (T_{SAR})
6. Evacuation time (T_E)

For clarity, the above factors are elaborated in the following

2.2.1 Time required to transmit distress alert (T_{TR1})

For determination of time required to transmit distress alert, the ship subject to accident is equipped with shipborne radio communication facilities on board. When a distress message is sent by a ship in distress, it will continue to transmit the same message automatically in every 3 ½ to 4 ½ minutes with 5 attempts [4]. However, the influence of weather condition, distance, and power of radiocommunication equipment are not taking into account.

2.2.2 Time required to acknowledge distress calls by Coast Stations (T_{ACK})

Acknowledgements of digital selective call (DSC) distress transmitted from the ship on MF or HF should be initiated by Coast Stations (SROP) with a minimum delay of 1 min after receipt of a distress call, and normally within a maximum delay of 2 ¾ min [4]. This allows all calls within a single frequency or multi-frequency call attempt to be completed and should allow sufficient time for Coast Stations to respond to the distress call. Acknowledgements by Coast Stations on VHF should be transmitted as soon as practicable [5]. Received and acknowledge distress call are to be relayed to BASARNAS for immediate action.

2.2.3 Time required to relay distress message to SAR office (T_{TR2})

Once the distress message has been received by SROP, it will immediately send to the nearest SAR office/post. There is no specific time required to transmit a distress message to SAR. However, as a reference, it is assumed that it is similar to the time required to transmit distress alert (T_{TR1}).

2.2.4 Response time of SAR team (T_R)

Response time is defined as preliminary time before start to rescue. It is determined from the receiving of distress calls to readiness of SAR personnel/SAR rescue unit to start mobilization to location of accident [6]. The following formula is to be used to determine response time:

$$T_R = T_1 + T_2 + T_3 \quad (1)$$

Where:
T_1 = Time for precom-excom (min)
T_2 = Briefing time (min)
T_3 = Time for preparation to dispatch of SAR team/personnel (min)

The response time of SAR teams will be different for each case. However, the following should be considered as influence factors:

1. Weather condition
2. Time of accident (day or night)
3. The availability/specification of facilities
4. Location of accident
5. Location of nearest SAR team

Table 2 shown the response time data for maritime disaster during 2017 [7].

Table 2. Response time of BASARNAS in 2017

No.	Location of SAR Office	Response time (min)	No.	Location of SAR Office	Response time (min)
1	SAR Banda Aceh	15,32	18	SAR Kendari	17,49
2	SAR Medan	44,01	19	SAR Ambon	33,54
3	SAR Pekanbaru	31,72	20	SAR Sorong	32,15

No.	Location of SAR Office	Response time (min)
4	SAR Padang	39,16
5	SAR Tanjung Pinang	49,65
6	SAR Palembang	43,54
7	SAR Jakarta	99,65
8	SAR Semarang	97,94
9	SAR Surabaya	22,56
10	SAR Denpasar	20,18
11	SAR Mataram	31,27
12	SAR Pontianak	17,77
13	SAR Banjarmasin	29,99
14	SAR Balikpapan	26,07
15	SAR Kupang	17,69
16	SAR Makassar	20,93
17	SAR Manado	30,50

No.	Location of SAR Office	Response time (min)
21	SAR Timika	121,10
22	SAR Biak	31,13
23	SAR Jayapura	28,50
24	SAR Merauke	17,00
25	SAR Bengkulu	20,00
26	SAR Jambi	26,66
27	SAR Pangkal Pinang	31,58
28	SAR Lampung	13,78
29	SAR Bandung	33,33
30	SAR Gorontalo	50,00
31	SAR Palu	16,79
32	SAR Ternate	17,63
33	SAR Manokwari	23,00
34	SAR Yogyakarta	20,00

2.2.4 Time required for rescue (T_{SAR})

Upon acknowledgement of distress calls or receiving the relay message from coast stations, the SAR team/personnel conduct a briefing and preparation for rescue including the facilities and equipment, information related to location of accident, weather condition etc. Furthermore, the following factors need to be considered for calculation of time required for rescue.

1. Location of accident
2. Capability of rescue boat

2.2.6 Evacuation time (T_E)

Evacuation time is the time required for passenger from receiving the evacuation the following components should be considered [8]:

1. awareness time (A) should be 10 min for the night time scenarios and 5 min for the day time scenarios;
2. travel time (T);
3. embarkation time (E) and;
4. launching time (L)

The following formula is used to calculate the evacuation time T_E:

$$1{,}25\ A + T + 2/3\ (E + L) \tag{2}$$

Therefore, the capacity of ESEP can be obtained by summing up the time factors above as given in Equation 3.

$$T_{ESEP} = T_{TR1} + T_{ACK} + T_{TR2} + T_R + T_{SAR} + T_E \tag{3}$$

3.0 DETERMINATION OF ESEP CAPACITY FOR RESTRICTED SERVICE SHIPS

In evaluation of ESEP capacity, the type of accident that could lead to start the operation of ESEP is to be considered. According to Table 1, the flooding in engine room is chosen as the nature of accident. Furthermore, the following condition is to be assumed:

- The accident location is in Indonesian area

- the ship is encountering black out
- the passenger and crew are retained on board ship during accident until the rescuer has been arrived on board
- ESEP is continuously to supply essential equipment for emergency.
- There are no nearest ships during accident
- GMDSS is available on board the ships
- The type of ship is passenger ship

During flooding, the machinery installations including the main engine, auxiliary engine and its supporting system are assumed out of service and the ship is encountering black out condition. Meanwhile, the ESEP is starting to supply essential equipment for emergency.

Based on above condition, the ESEP should have sufficient capacity to provide necessary power for emergency essential services until the Rescuers arrive onboard. In this circumtance, the capacity of ESEP will be calculated in accordance with the provision specified in sub section 2 above.

1. Time required to transmit distress alert (T_{TR1})
According to sub section 2.2.1 above, 4 ½ m is chosen as the time required to transmit distress message by the distress ship until acknowledged by SROP.

2. Time required to acknowledge distress calls by Coast Stations (T_{ACK})
According to sub section 2.2.2 above, 2 ¾ min is chosen as the delay in acknowledge distress message by SROP.

3. Time required to relay distress message to SAR office (T_{TR2})
According to sub section 2.2.3 above, 2 ¾ min is chosen as the time required to transmit distress message by SROP to SAR office.

4. Response time of SAR team (T_R)
The response time of SAR team is varied for each post. The response time is selected according to the location of SAR post in Table 2.

5. Time required for rescue (T_{SAR})
In determination of T_{SAR}, the following factors are to be defined:

- Location of accident ship, the locations of accident ship should be defined. In this calculation, the locations of accident ship were made according to general route/channel of ship. 10 points are selected randomly for three difference area, under 200 NM, 50 NM and 20 NM from coast. Figure 3 below shows the distribution of accident location for each area.
- Capability of rescue boat, BASARNAS is facilitated with rescue boat (RB) having three different size, RB 40 meter, RB 36 meter and RB 28 meter. The total number of the boats are 33 units which are distributed to each SAR post as shown in Figure 3 below. These boats have a service speed approx. 23 – 25 knots and can be operate on sea state 3 (max. wave 1,25 m).
- Nearest SAR post, the nearest SAR post to the accident ship is selected. It is assumed that SROP will forward the distress message to the nearest SAR post firstly. Hence the rescue operation can be performed quickly.

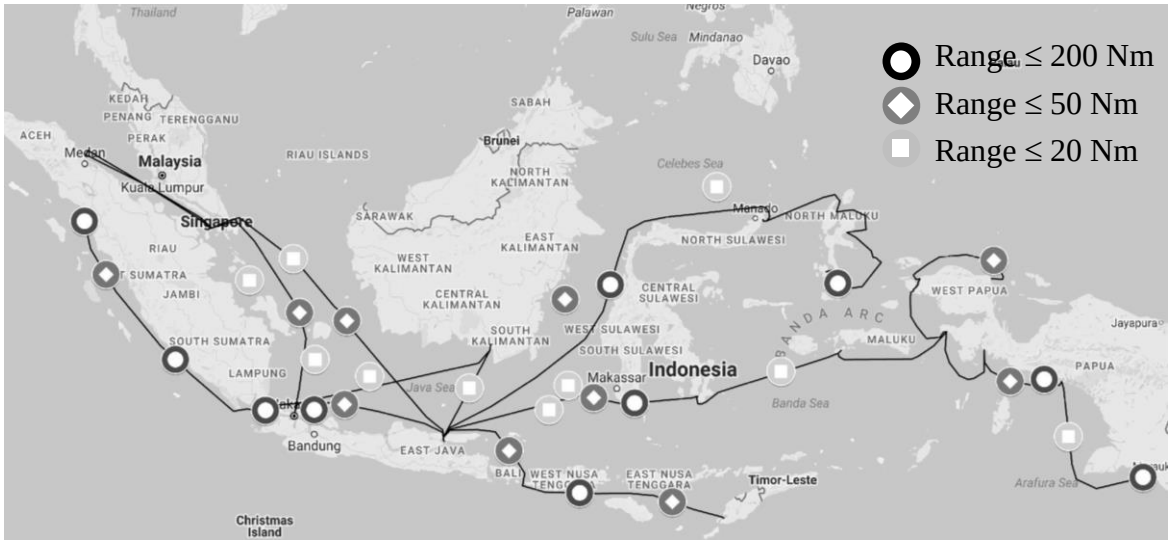

Figure 3: Distribution of accident ships for each range [10]

6. Evacuation time (T_E)

Evacuation time is taken from the calculation given in the IMO MSC/Circ.1033 "Interim guidelines for evacuation analyses for new and existing passenger ships". In this case 40 minutes is chosen as the evacuation time for passenger ships.

The capacity of ESEP can be calculated by summing up all of factors as described above. By the spread sheet calculation, the total capacity of ESEP can be calculated and the result for each range is shown in the following Table 3, 4 and 5:

Table 3. Capacity of ESEP for range up to 200 Nm

Loc.	Coordinate	Nearest SAR post	Distance to SAR post [km]	T_{RSC} [min]	T_E [min]	$T_{TR1,2}$ [min]	T_{ACK} [min]	T_{SAR} [min]	T_{TOTAL} [min]	T_{TOTAL} [H]
Post 1	-5.96311, 116.78737	Mataram	298,172	420	40	9	2,75	27,66	499,41	8,32
Post 2	-5.02539, 117.53164	Makassar	222,24	313,04	40	9	2,75	25,8	390,59	6,50
Post 3	-4.47785, 125.8374	Ambon	264,836	373,04	40	9	2,75	27,78	452,57	7,54
Post 4	1.40143, 125.01444	Manado	209,276	294,78	40	9	2,75	28,42	374,95	6,24
Post 5	-0.09887, 106.80908	Pontianak	259,28	365,21	40	9	2,75	25,89	442,85	7,38
Post 6	-4.68037, 109.78633	Semarang	253,724	357,39	40	9	2,75	26,44	435,58	7,25
Post 7	-5.12377, 113.67553	Surabaya	281,504	396,52	40	9	2,75	25,69	473,96	7,89
Post 8	-4.01769, 107.65503	Jakarta	244,464	344,34	40	9	2,75	25,33	421,42	7,02
Post 9	-0.93379, 105.09521	Tjg. pinang	231,5	326,08	40	9	2,75	28,96	406,79	6,77
Post 10	-9.57928, 121.58558	Kupang	227,796	320,86	40	9	2,75	27,49	400,10	6,66
Average										7,16

Table 4. Capacity of ESEP for range up to 50 Nm

Loc.	Coordinate	Nearest SAR post	Distance to SAR post [km]	T_{RSC} [min]	T_E [min]	$T_{TR1,2}$ [min]	T_{ACK} [min]	T_{SAR} [min]	T_{TOTAL} [min]	T_{TOTAL} [H]
Post 1	-7.54227, 115.23009	Buleleng	64,8	91,27	40	9	2,75	24,61	167,63	2,79

Loc.	Coordinate	Nearest SAR post	Distance to SAR post [km]	T_{RSC} [min]	T_E [min]	$T_{TR1,2}$ [min]	T_{ACK} [min]	T_{SAR} [min]	T_{TOTAL} [min]	T_{TOTAL} [H]
Post 2	-2.19671, 107.05078	Pkl. Pinang	104	146,49	40	9	2,75	28,47	226,71	3,7785
Post 3	-2.51506, 108.89648	Ketapang	143	201,42	40	9	2,75	25,89	279,06	4,65
Post 4	-0.71409, 99.50042	Padang	95	133,81	40	9	2,75	24,86	210,42	3,50
Post 5	-5.4957, 118.53149	Makassar	125	176,07	40	9	2,75	25,8	253,62	4,22
Post 6	-4.85562, 134.78027	Timika	238	335,24	40	9	2,75	25,98	412,97	6,88
Post 7	-5.7581, 108.80859	Cirebon	109	153,53	40	9	2,75	25,17	230,45	3,84
Post 8	-1.67517, 117.40539	Mamuju	195	274,67	40	9	2,75	25,8	352,22	5,87
Post 9	-0.1593, 134.13757	Manokwari	82,1	115,64	40	9	2,75	22,25	189,64	3,16
Post 10	-9.51678, 121.59118	Kupang	234	329,60	40	9	2,75	27,49	408,84	6,81
Average										4,55

Table 5. Capacity of ESEP for range up to 20 Nm

Loc.	Coordinate	Nearest SAR post	Distance to SAR post [km]	T_{RSC} [min]	T_E [min]	$T_{TR1,2}$ [min]	T_{ACK} [min]	T_{SAR} [min]	T_{TOTAL} [min]	T_{TOTAL} [H]
Post 1	-5.98658, 105.72553	Banten	32	45,07	40	9	2,75	25,30	122,12	2,04
Post 2	-1.05473, 128.05614	Ternate	88,7	124,94	40	9	2,75	24,68	201,37	3,36
Post 3	-5.96868, 107.61693	Jakarta	83,7	117,90	40	9	2,75	25,33	194,98	3,25
Post 4	-5.70891, 120.13	Selayar	59,9	84,37	40	9	2,75	25,80	161,92	2,70
Post 5	-9.16717, 117.98217	Kayangan	223	314,11	40	9	2,75	27,66	393,52	6,56
Post 6	-1.11504, 119.18518	Palu	123	173,26	40	9	2,75	26,61	251,62	4,19
Post 7	-4.02317, 102.20855	Bengkulu	25,7	36,20	40	9	2,75	24,41	112,36	1,87
Post 8	-7.25894, 138.09265	Agats	184	259,18	40	9	2,75	25,98	336,91	5,62
Post 9	-4.78994, 136.10687	Timika	96,2	135,51	40	9	2,75	25,98	213,24	3,55
Post 10	1.36492, 98.6531	Sibolga	38,3	53,95	40	9	2,75	28,11	133,81	2,23
Average										3,53

3.0 CONCLUSIONS

In this paper, the capacity of ESEP for ship operated in Indonesian water is evaluated. The capacity of ESEP depends on several factors namely the range of ships operation, time required to transmit distress call, time required to acknowledge distress call by SROP, time required to relay distress message to SAR office/post, the response time of SAR team, the evacuation time of passenger and search and rescue time. The result of evaluation shows that the capacity of ESEP is directly proportional to the range of operation of ship. The most significant factor affecting the capacity of ESEP is a rescue time (T_{RSC}). It depends on the facilities for SAR operation as well as the weather condition. Considering those crucial factors, we obtain the capacity of ESEP for Ships navigating in Indonesia water which is only 7,16 hours for service range up to 200 Nm, 4,55 hours for service range up to 50 Nm and 3,53 hours for service range up to 20 Nm. Thus, from the obtained results it is obviously that the capacity of ESEP for ships in consideration have lower capacity than those of international voyage.

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