



```

81 0 2 383.40335 0 1451 568.00000 383.40335 32.5% - 62s
82 27 28 384.48220 7 1511 568.00000 383.61230 32.5% 141 73s
83 362 371 386.04700 88 1433 568.00000 383.61230 32.5% 14.8 75s
84 1999 2049 398.64186 492 1135 568.00000 383.61230 32.5% 8.1 80s
85 2791 2817 452.69518 682 934 568.00000 383.61230 32.5% 31.4 85s
86 3201 3129 436.79966 89 1455 568.00000 384.24682 32.4% 36.0 95s
87 3204 3131 541.00000 588 99 568.00000 541.00000 4.75% 35.9 101s
88 3207 3133 542.60937 375 339 568.00000 542.60937 4.47% 35.9 105s
89 3214 3138 547.19211 557 674 568.00000 547.19211 3.66% 35.8 110s
90 3223 3144 552.10654 172 530 568.00000 552.10654 2.80% 35.7 116s
91 3226 3146 553.71201 464 333 568.00000 553.71201 2.52% 35.7 120s
92 3235 3152 554.43232 218 439 568.00000 554.43232 2.39% 35.6 127s
93 3244 3158 555.50326 650 581 568.00000 555.50326 2.20% 35.5 130s
94 3249 3161 555.71787 36 480 568.00000 555.71787 2.16% 35.4 137s
95 3252 3163 555.86092 116 482 568.00000 555.86092 2.14% 35.4 142s
96 3255 3165 555.95807 620 518 568.00000 555.95807 2.12% 35.4 151s
97 3258 3167 556.10610 225 483 568.00000 556.10610 2.09% 35.3 180s
98 3261 3169 556.10771 15 458 568.00000 556.10771 2.09% 35.3 185s
99 3262 3170 556.27416 451 501 568.00000 556.27416 2.06% 35.3 196s
100 3266 3172 556.31067 64 483 568.00000 556.31067 2.06% 35.2 200s
101 3267 3173 556.46508 682 526 568.00000 556.46508 2.03% 35.2 212s
102 3269 3174 556.52006 113 500 568.00000 556.52006 2.02% 35.2 215s
103 3273 3177 556.68014 210 486 568.00000 556.68014 1.99% 35.2 229s
104 3274 3178 556.73835 336 533 568.00000 556.73835 1.98% 35.2 230s
105 3278 3180 556.77856 410 532 568.00000 556.77856 1.98% 35.1 235s
106 3279 3181 557.17279 114 538 568.00000 557.17279 1.91% 35.1 251s
107 3281 3182 557.34167 505 571 568.00000 557.34167 1.88% 35.1 256s
108 3285 3185 557.53376 349 537 568.00000 557.53376 1.84% 35.0 274s
109 3286 3186 557.56659 110 533 568.00000 557.56659 1.84% 35.0 278s
110 3289 3188 557.59355 119 521 568.00000 557.59355 1.83% 35.0 280s
111 3290 3188 557.70187 288 487 568.00000 557.70187 1.81% 35.0 292s
112 3293 3190 557.74688 700 500 568.00000 557.74688 1.81% 35.0 295s
113 3295 3192 557.88219 599 468 568.00000 557.88219 1.78% 34.9 304s
114 3296 3192 557.96072 53 535 568.00000 557.96072 1.77% 34.9 306s
115 3301 3196 558.07287 89 505 568.00000 558.07287 1.75% 34.9 323s
116 3302 3196 558.09806 435 470 568.00000 558.09806 1.74% 34.9 329s
117 3303 3197 558.10800 287 521 568.00000 558.10800 1.74% 34.8 331s
118 3306 3199 558.15294 244 532 568.00000 558.15294 1.73% 34.8 355s
119 3307 3200 558.16721 375 542 568.00000 558.16721 1.73% 34.8 364s
120 3308 3200 558.17634 597 513 568.00000 558.17634 1.73% 34.8 370s
121 3310 3202 558.18373 299 522 568.00000 558.18373 1.73% 34.8 379s
122 3311 3202 558.20883 448 482 568.00000 558.20883 1.72% 34.8 425s
123 3315 3205 558.24548 563 476 568.00000 558.24548 1.72% 34.7 431s
124 3319 3208 558.28011 282 497 568.00000 558.28011 1.71% 34.7 436s
125 3328 3215 558.31296 56 219 568.00000 558.31296 1.71% 66.5 440s
126 3368 3244 564.52448 670 94 568.00000 564.52448 0.61% 66.9 445s
127 3486 3251 cutoff 49 568.00000 566.00000 0.35% 70.4 450s
128
129 Cutting planes:
130 Learned: 1
131 Gomory: 9
132 Lift-and-project: 17
133 Cover: 2
134 Implied bound: 3
135 MIR: 25
136 StrongCG: 4
137 Flow cover: 44
138 Zero half: 6
139 RLT: 8
140 Relax-and-lift: 89
141
142 Explored 3588 nodes (271220 simplex iterations) in 451.22 seconds (267.55 work units)
143 Thread count was 8 (of 8 available processors)
144
145 Solution count 3: 568 568 568
146 No other solutions better than 568
147
148 Optimal solution found (tolerance 1.00e-04)
149 Best objective 5.6800000000000e+02, best bound 5.6800000000000e+02, gap 0.0000%
150
151 Output optimal solution and the Optimal Obj: 568.0
152
153
154 Obj = 568.0
155
156 Solutions:
157 The total pi = 122.0
158 The total duration time in berth stage = 122.0
159 The total duration time in quay crane scheduling stage = 28.0
160 The total departure time in berth stage= 331.0
161 The total departure time in quay crane scheduling stage = 237.0
162 The total wasted crane work hour according QC0= 12.944538847840269
163 The last depature time in quay crane scheduling stage = 51.0
164

```

```
165 The specific solution are as follows:
166 Vessel i: 0: li: 6, pi: 28-34, ai-di: 24-33, taoi-deltai: 24-33, periodi: 9, taoPi_SP-deltaPi_SP
: 24-26, periodPi: 2, c_i: 2148120, dowork: 2240974, fa_i: 4
167 Vessel i: 1: li: 5, pi: 23-28, ai-di: 28-41, taoi-deltai: 28-41, periodi: 13, taoPi_SP-
deltaPi_SP: 28-31, periodPi: 3, c_i: 3207287, dowork: 3822838, fa_i: 3
168 Vessel i: 2: li: 4, pi: 14-18, ai-di: 24-44, taoi-deltai: 24-44, periodi: 20, taoPi_SP-
deltaPi_SP: 24-28, periodPi: 4, c_i: 5157909, dowork: 5272880, fa_i: 4
169 Vessel i: 3: li: 7, pi: 7-14, ai-di: 48-67, taoi-deltai: 48-67, periodi: 19, taoPi_SP-deltaPi_SP
: 48-51, periodPi: 3, c_i: 4844899, dowork: 5536524, fa_i: 5
170 Vessel i: 4: li: 7, pi: 23-30, ai-di: 44-56, taoi-deltai: 44-54, periodi: 10, taoPi_SP-
deltaPi_SP: 44-46, periodPi: 2, c_i: 2392061, dowork: 2636440, fa_i: 3
171 Vessel i: 5: li: 5, pi: 18-23, ai-di: 28-60, taoi-deltai: 28-53, periodi: 25, taoPi_SP-
deltaPi_SP: 28-37, periodPi: 9, c_i: 6496954, dowork: 6986566, fa_i: 2
172 Vessel i: 6: li: 5, pi: 9-14, ai-di: 13-47, taoi-deltai: 13-39, periodi: 26, taoPi_SP-deltaPi_SP
: 13-18, periodPi: 5, c_i: 6745562, dowork: 7909320, fa_i: 4
173 TimeSolveModel: 459.000000
174
175 TimeAll: 462.000000
176
177
```