

**Table S1.** The profiles of interviewees.

Experts	Work organization	Role	Experience	Interview method
Expert A	China University of Mining & Technology (Beijing)	Professor	21 years	Face-to-face
Expert B	China University of Geosciences (Beijing)	Professor	18 years	Face-to-face
Expert C	Liaoning Technical University	Professor	24 years	Email
Expert D	Zhengzhou Coal Industry (Group) Co., Ltd.	Senior Engineer	14 years	Face-to-face
Expert E	Jizhong Energy Group Co., Ltd.	Senior Engineer	17 years	Email
Expert F	Shanxi Coking Coal Group Co., Ltd.	Senior Engineer	11 years	Face-to-face
Expert G	Huayang New Material Technology Group Co., Ltd	Senior Engineer	13 years	Email

**Table S2.** The direct-relation matrix of the representative risk factors of gas explosions.

[illegible]

$F_{14}$	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
$F_{15}$	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
$F_{16}$	0	4	0	4	4	3	0	0	0	0	0	0	0	0	0	0	0	2	0	3	0
$F_{17}$	2	4	0	3	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
$F_{18}$	0	0	0	4	3	0	3	2	0	0	0	0	0	0	0	0	0	0	0	2	2
$F_{19}$	2	0	0	0	0	0	0	2	2	0	0	0	0	0	2	0	2	0	0	2	0
$F_{20}$	0	0	0	0	0	4	4	3	2	2	0	0	0	0	0	0	0	0	0	0	0
$F_{21}$	0	0	0	0	0	0	0	0	0	0	0	2	2	2	0	0	0	0	0	0	0

**Table S3.** The total-relation matrix of the representative risk factors of gas explosions.

	$F_1$	$F_2$	$F_3$	$F_4$	$F_5$	$F_6$	$F_7$	$F_8$	$F_9$	$F_{10}$	$F_{11}$	$F_{12}$	$F_{13}$	$F_{14}$	$F_{15}$	$F_{16}$	$F_{17}$	$F_{18}$	$F_{19}$	$F_{20}$	$F_{21}$
$F_1$	0	0	0	0.01	0.01	0	0.01	0	0.01	0.01	0	0	0	0	0	0	0	0	0	0	0.01
$F_2$	0	0	0	0.0225	0.0225	0.01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.01
$F_3$	0.01	0.01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
$F_4$	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
$F_5$	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
$F_6$	0	0	0	0	0	0	0	0	0	0	0	0.0225	0	0.01	0.01	0	0	0	0	0	0
$F_7$	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
$F_8$	0	0	0	0	0	0	0	0	0	0	0	0.01	0.01	0.01	0	0	0	0	0	0	0
$F_9$	0	0	0	0	0	0	0	0	0	0	0	0.01	0.01	0.01	0	0	0	0	0	0	0
$F_{10}$	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
$F_{11}$	0	0	0	0	0	0	0	0	0	0.01	0	0.01	0.04	0.0225	0.01	0	0	0	0	0	0
$F_{12}$	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
$F_{13}$	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
$F_{14}$	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
$F_{15}$	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
$F_{16}$	0	0.04	0	0.05	0.049	0.0303	0	0	0	0	0	0	0	0	0	0	0	0.01	0	0.024	0
$F_{17}$	0.01	0.04	0	0.0285	0.0285	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
$F_{18}$	0	0	0	0.04	0.0225	0	0.0255	0.0115	0	0	0	0	0	0	0	0	0	0	0	0.01	0.01
$F_{19}$	0.01	0	0	0	0	0	0	0.0115	0.0121	0	0	0	0	0	0.0102	0	0.01	0	0	0.01	0

$F_{20}$	0	0	0	0	0	0.04	0.04	0.0225	0.01	0.01	0	0	0	0	0	0	0	0	0	0	0
$F_{21}$	0	0	0	0	0	0	0	0	0	0	0	0.01	0.01	0.01	0	0	0	0	0	0	0

**Table S4.** The overall effect matrix of the representative risk factors of gas explosions.

	$F_1$	$F_2$	$F_3$	$F_4$	$F_5$	$F_6$	$F_7$	$F_8$	$F_9$	$F_{10}$	$F_{11}$	$F_{12}$	$F_{13}$	$F_{14}$	$F_{15}$	$F_{16}$	$F_{17}$	$F_{18}$	$F_{19}$	$F_{20}$	$F_{21}$
$F_1$	1	0	0	0.01	0.01	0	0.01	0	0.01	0.01	0	0	0	0	0	0	0	0	0	0	0.01
$F_2$	0	1	0	0.0225	0.0225	0.01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.01
$F_3$	0.01	0.01	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
$F_4$	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
$F_5$	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
$F_6$	0	0	0	0	0	1	0	0	0	0	0	0.0225	0	0.01	0.01	0	0	0	0	0	0
$F_7$	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
$F_8$	0	0	0	0	0	0	0	1	0	0	0	0.01	0.01	0.01	0	0	0	0	0	0	0
$F_9$	0	0	0	0	0	0	0	0	1	0	0	0.01	0.01	0.01	0	0	0	0	0	0	0
$F_{10}$	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
$F_{11}$	0	0	0	0	0	0	0	0	0	0.01	1	0.01	0.04	0.0225	0.01	0	0	0	0	0	0
$F_{12}$	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
$F_{13}$	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
$F_{14}$	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
$F_{15}$	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
$F_{16}$	0	0.04	0	0.05	0.049	0.0303	0	0	0	0	0	0	0	0	0	1	0	0.01	0	0.024	0
$F_{17}$	0.01	0.04	0	0.0285	0.0285	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
$F_{18}$	0	0	0	0.04	0.0225	0	0.0255	0.0115	0	0	0	0	0	0	0	0	0	1	0	0.01	0.01
$F_{19}$	0.01	0	0	0	0	0	0	0.0115	0.0121	0	0	0	0	0	0.0102	0	0.01	0	1	0.01	0
$F_{20}$	0	0	0	0	0	0.04	0.04	0.0225	0.01	0.01	0	0	0	0	0	0	0	0	0	1	0
$F_{21}$	0	0	0	0	0	0	0	0	0	0	0	0.01	0.01	0.01	0	0	0	0	0	0	1

**Table S5.** The reachability matrix of the representative risk factors of gas explosions.

	$F_1$	$F_2$	$F_3$	$F_4$	$F_5$	$F_6$	$F_7$	$F_8$	$F_9$	$F_{10}$	$F_{11}$	$F_{12}$	$F_{13}$	$F_{14}$	$F_{15}$	$F_{16}$	$F_{17}$	$F_{18}$	$F_{19}$	$F_{20}$	$F_{21}$	Driving Power
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$F_1$	1	0	0	1	1	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0	1	7
$F_2$	0	1	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	5
$F_3$	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
$F_4$	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
$F_5$	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
$F_6$	0	0	0	0	0	1	0	0	0	0	0	1	0	1	1	0	0	0	0	0	0	4
$F_7$	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
$F_8$	0	0	0	0	0	0	0	1	0	0	0	1	1	1	0	0	0	0	0	0	0	4
$F_9$	0	0	0	0	0	0	0	0	1	0	0	1	1	1	0	0	0	0	0	0	0	4
$F_{10}$	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1
$F_{11}$	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	0	0	0	0	0	0	6
$F_{12}$	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1
$F_{13}$	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1
$F_{14}$	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1
$F_{15}$	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1
$F_{16}$	0	1	0	1	1	1	0	0	0	0	0	0	0	0	0	1	0	1	0	1	0	7
$F_{17}$	1	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	5
$F_{18}$	0	0	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	1	0	1	1	7
$F_{19}$	1	0	0	0	0	0	0	1	1	0	0	0	0	0	1	0	1	0	1	1	0	7
$F_{20}$	0	0	0	0	0	1	1	1	1	1	0	0	0	0	0	0	0	0	0	1	0	6
$F_{21}$	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0	0	0	1	4
Dependence Power	4	4	1	6	6	4	4	4	4	4	1	6	5	6	4	1	2	2	1	4	4	

**Table S6.** The results of the level partitions of the reachability matrix Iteration I to Iteration IV.

Representative risk factors	Reachability set	Antecedent set	Intersection set	Level
$F_1$	$F_1, F_4, F_5, F_7, F_9, F_{10}, F_{21}$	$F_1, F_3, F_{17}, F_{19}$	$F_1$	III
$F_2$	$F_2, F_4, F_5, F_6, F_{21}$	$F_2, F_3, F_{16}, F_{17}$	$F_2$	III
$F_3$	$F_1, F_2, F_3$	$F_3,$	$F_3$	IV
$F_4$	$F_4$	$F_1, F_2, F_4, F_{16}, F_{17}, F_{18}$	$F_4$	I

$F_5$	$F_5$	$F_1, F_2, F_5, F_{16}, F_{17}, F_{18}$	$F_5$	I
$F_6$	$F_6, F_{12}, F_{14}, F_{15}$	$F_2, F_6, F_{16}, F_{20}$	$F_6$	II
$F_7$	$F_7$	$F_1, F_7, F_{18}, F_{20}$	$F_7$	I
$F_8$	$F_8, F_{12}, F_{13}, F_{14}$	$F_8, F_{18}, F_{19}, F_{20}$	$F_8$	II
$F_9$	$F_9, F_{12}, F_{13}, F_{14}$	$F_1, F_9, F_{19}, F_{20}$	$F_9$	II
$F_{10}$	$F_{10}$	$F_1, F_{10}, F_{11}, F_{20}$	$F_{10}$	I
$F_{11}$	$F_{10}, F_{11}, F_{12}, F_{13}, F_{14}, F_{15}$	$F_{11}$	$F_{11}$	II
$F_{12}$	$F_{12}$	$F_6, F_8, F_9, F_{11}, F_{12}, F_{21}$	$F_{12}$	I
$F_{13}$	$F_{13}$	$F_8, F_9, F_{11}, F_{13}, F_{21}$	$F_{13}$	I
$F_{14}$	$F_{14}$	$F_6, F_8, F_9, F_{11}, F_{14}, F_{21}$	$F_{14}$	I
$F_{15}$	$F_{15}$	$F_6, F_{11}, F_{15}, F_{19}$	$F_{15}$	I
$F_{16}$	$F_2, F_4, F_5, F_6, F_{16}, F_{18}, F_{20}$	$F_{16},$	$F_{16}$	V
$F_{17}$	$F_1, F_2, F_4, F_5, F_{17}$	$F_{17}, F_{19}$	$F_{17}$	IV
$F_{18}$	$F_4, F_5, F_7, F_8, F_{18}, F_{20}, F_{21}$	$F_{16}, F_{18}$	$F_{18}$	IV
$F_{19}$	$F_1, F_8, F_9, F_{15}, F_{17}, F_{19}, F_{20}$	$F_{19}$	$F_{19}$	V
$F_{20}$	$F_6, F_7, F_8, F_9, F_{10}, F_{20}$	$F_{16}, F_{18}, F_{19}, F_{20}$	$F_{20}$	III
$F_{21}$	$F_{12}, F_{13}, F_{14}, F_{21}$	$F_1, F_2, F_{18}, F_{21}$	$F_{21}$	II